ELEMENTS OF BOTANY

By the same.

I.

CLASS-BOOK OF BOTANY,

INTRODUCTION TO THE STUDY OF THE VEGETABLE KINGDOM.

Third Edition, 1871. One large vol. 8vo, with 1800 Illustrations. Price 21s.

II.

MANUAL OF BOTANY,

INTRODUCTION TO THE STUDY OF THE STRUCTURE, PHYSIOLOGY, AND CLASSIFICATION OF PLANTS.

Fifth Edition, 1875. Crown 8vo, with 963 Illustrations. Price 12s. 6d.

Professor Balfour has published many excellent text-books on Botany, but none of them, we think, so useful and so comprehensive as his *Manual*, the fifth edition of which is now before us. Although the preface does not inform us, yet we observe by comparing this edition with the last, published in 1860, that much of it has been re-written and new illustrations added, so that the work has been brought up to the present time. The chapters on geographical and fossil botany, as well as that on the use of the microscope in vegetable histology, have been entirely remodelled. An excellent glossary of botanical terms is given, and, what adds much to the usefulness of the book, a remarkably complete index. There is no work in the English language with which we are acquainted that treats in so comprehensive and accurate a manner all the departments of botany, and therefore we conscientiously recommend the "Manual" to all teachers and students of the science as a complete and safe text-book.—*Scotsman.*

III.

INTRODUCTION TO PALÆONTOLOGICAL BOTANY.

8vo, Illustrated. Price 7s. 6d.

IV.

THE BOTANIST'S COMPANION,

DIRECTIONS FOR THE USE OF THE MICROSCOPE, AND FOR THE COLLECTION AND PRESERVATION OF PLANTS, WITH A FULL GLOSSARY OF BOTANICAL TERMS.

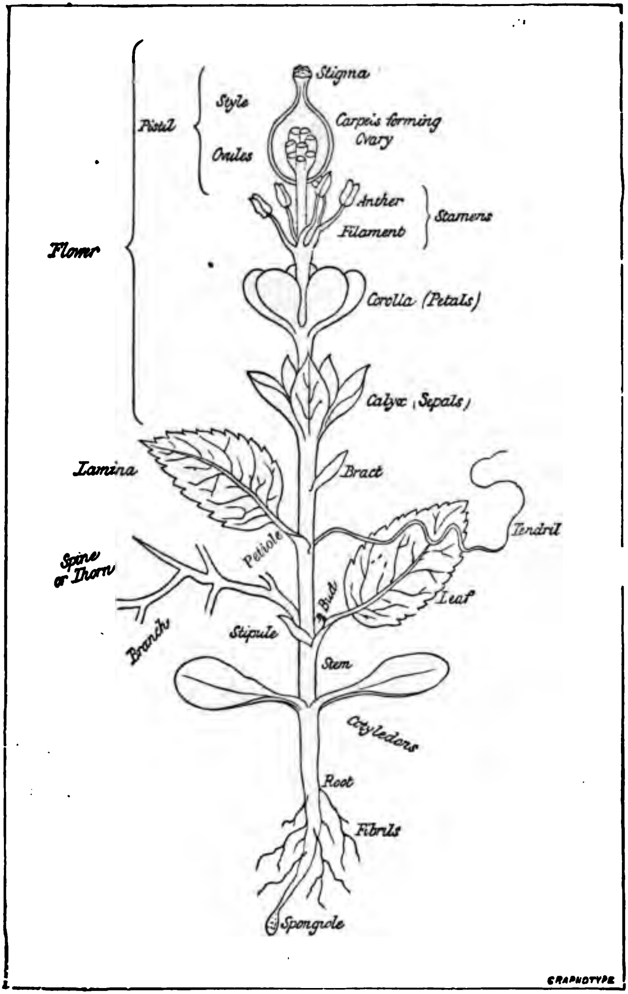
Second Edition, 1875. Crown 8vo. Price 2s. 6d.

V.

THE FLORA OF EDINBURGH.

Second Edition. Fcap. 8vo. Price 3s. 6d.

FRONTISPIECE. FIG. 1.



IDEAL PLANT.

THE

ELEMENTS OF BOTANY

FOR THE USE OF SCHOOLS

BY

JOHN HUTTON BALFOUR, M.D.

F.R.SS.L. & E., F.L.S.

PROFESSOR OF MEDICINE AND BOTANY IN THE

UNIVERSITY OF EDINBURGH

THIRD EDITION

EDINBURGH

ADAM AND CHARLES BLACK

1876

Printed by R. & R. Clark, *Edinburgh.*

INTRODUCTORY REMARKS.

Natural Science, or, in other words, a knowledge of the objects in the material world around us, is now becoming an important part of education in schools. It is generally allowed that the young should not confine their attention entirely to languages, arithmetic, and mathematics, but that they should extend their studies, and acquire information regarding the structure of the globe, and of the animals and plants with which it is stocked. Classical literature undoubtedly forms an important groundwork in the education of youth, and the acquisition of modern languages cannot be overlooked. But something more is wanted to make our students of arts useful members of society. They must be able to take an intelligent view of God's works, by embracing some department of Natural History in their course of study. The Natural Sciences are well fitted to call forth the faculty of observation, to inculcate correctness of description, accuracy of diagnosis, and orderly arrangement. All these qualities are of great importance in the ordinary affairs of life.

A proposal has been made that at least one subject in Natural Science shall be professed by every one who

appears for an examination in Arts in our Universities. Examinations are now held in the University of Edinburgh for graduation in Arts with honours in the departments of Botany, Zoology, Geology, and Chemistry. This seems to be a step in a right direction, and the carrying out of the plan will have an important influence on the system of education in our schools and colleges. The High School of Edinburgh, and other schools both in Scotland and in England, have already made a successful move in this direction. The Science and Art Department are encouraging the study of science, and examinations are held for the purpose of testing the qualifications of those who are to be certified teachers in our educational establishments, and who are to direct the studies of the young in the paths of science. The examinations in Botany, Natural History, and Chemistry, conducted by the Highland and Agricultural Society of Scotland, have operated most beneficially on students of Agriculture. Botany is also included in the examinations of Veterinary students. The institution of Degrees in Science, and the founding of valuable scholarships, in the University of Edinburgh, are well calculated to foster a taste for scientific pursuits. The efforts made now-a-days to promote the higher education of women will also undoubtedly lead to more general attention to Natural History. The influence which women exercise over the studies of the young, and the position which they occupy in society, will thus be made subservient to the advance of science.

Among the natural sciences none is more fitted for general education than Botany. It relates to objects

which are constantly within our reach, and can be studied at all times. It is fitted alike for young and old, for rich and poor. It carries us to the fields, and makes us see wonderful beauty and arrangement even in the meanest weed. It adds brightness and pleasure to the hours of recreation. The prosecution of the science does not call for any cruel experiments, or for any proceedings which could inflict a wound on the most sensitive heart. It is the simplest of the sciences, and seems to be well calculated to initiate natural history studies.

The object of the present work is to give the principles of Botany in a plain manner, and to use only in the text such technical words as are essential for the beginner. In the notes explaining the woodcuts certain additional terms are given, which are considered to be suitable for more advanced pupils. In the First Part of the work the structure and functions of the various organs of plants are considered, from the root to the perfect fruit and seed, and the facts are illustrated by woodcuts. In the Second Part the subject of Classification is discussed; and here it is that a more extensive use of technical terms is required. An attempt has been made to give the systems of arrangement in such a way as to be comprehended by the young student; and descriptions are given of some of the common weeds, with the view of illustrating the subject and of encouraging the examination of those plants which are within the reach of every one. At the end of each division a series of questions is given, in order to direct the attention both of the teacher and of the pupil, to the

facts which require to be impressed on the memory. In the Glossary at the end an explanation is given of the terms employed, and the Index contains references to the places where these terms are more fully explained.

The works of God are wonderful, and they are sought out of all that have pleasure therein. Let a student acquire a taste for science, and he will proceed to search out more and more the objects around him. But while prosecuting with ardour the study of material things, let him not be misled by a false glare of science, which would lead him to ignore the power, the omniscience, and the constant superintendence of Him by whom all things were created, and by whom they subsist every moment; and, while diligently acquiring a knowledge of earthly things, let him not forget the better things of God's Word, which alone can make him wise unto salvation.

27 Inverleith Row, Edinburgh,
February 1876.

TABLE OF CONTENTS.

CHAPTER II.

PART II.

PART I.

THE STRUCTURE AND FUNCTIONS OF THE VARIOUS ORGANS OF PLANTS.

CHAPTER I.

THE ORGANS OF NUTRITION.

A PLANT consists of certain parts called *Organs*, which assume various forms, according to the functions which they perform in the economy of vegetable life. These organs, generally speaking, are denominated Root, Stem, Leaves, and Flowers. The first three are specially concerned in the nourishment of the plant, and are called Nutritive Organs; while the flowers are connected with the production of fruit and seed, and the continuance of the species, and are called Reproductive Organs. There is a common axis, one part of which penetrates the earth, constituting the root-system or *Descending axis*, while the other rises into the air, bearing leaves and flowers, and forms the stem-system or *Ascending axis*. Each of these parts gives origin to buds, which in the former are developed as roots and rootlets, in the latter as leaves and leaflets of various kinds. The ordinary leaf may be said to be the type of the organs connected with the ascending portion of the axis. This type undergoes various modifications. Some leaves are green, others

are coloured—some are placed close together or united, others are separated—some are thick and fleshy, others are thin and membranous, or mere scales—some are flat, others are folded so as to become hollow—some are changed into tendrils, others into thorns. The leaflets forming the flowers are usually very different in aspect from the ordinary leaves. It will be found, however, that they are all formed according to the leaf-law, and that they often show this in an evident manner when altered by cultivation or otherwise.

Fig. 1 (*Frontispiece*) represents an ideal plant with its different parts. There is a general axis from which proceeds the descending part, forming the root, with its fibrils, the extremities of which are called spongioles; and the ascending part, forming the stem, with its various joints or divisions. On the stem, leaves are developed, first in the form of temporary seed-leaves (cotyledons), and then in the form of simple or compound leaves. Buds are formed at the points where these leaves join the stem, from which proceed branches. In process of time the flower is produced, consisting of calycine leaves or sepals, corolline leaves or petals, staminal leaves or stamens, and pistilline leaves or carpels which form the ovary, and cover the young seeds or ovules. The latter are either attached to the edges of the carpels, or are produced at the extremity of the ascending axis. In this ideal figure, the parts of the flower or blossom are represented as separated from each other by spaces. In general they are found close to each other in nature.

Such is an enumeration of the organs of plants. We shall now proceed to consider them in succession,

commencing with their structure, as observed by means of the microscope.

I.—On the Microscopic Structure of Plants.

As regards their minute structure, plants have been

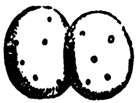


Fig. 2.

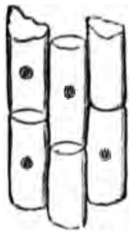


Fig. 3.

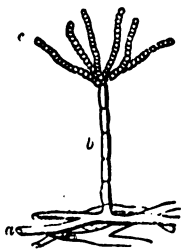


Fig. 5.

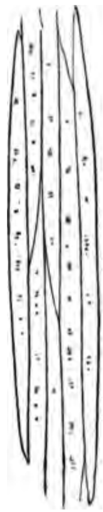


Fig 4.

divided into those which are composed entirely of small

Fig. 2.—Two cells or vesicles (magnified) which enter into the composition of plants. The dots are places where the membrane, forming the walls of the cells, is thin.

Fig. 3.—Cylindrical cells (magnified) united together and forming cellular tissue. Some of them are represented as containing small cellules or nuclei which are employed in the production of new cells.

Fig. 4.—Elongated spindle-shaped woody tubes, closed at each end, and united together, so as to form a kind of vascular or bast tissue (magnified). By maceration they form the pulp of paper.

Fig. 5.—Parasitic fungus constituting a kind of mould (*Penicillium*). There are root-like processes below which form the

bladders or vesicles called *Cells* (fig. 2), united together in various ways (fig. 3); and those which are furnished not only with cells, but with long closed tubes called *Vessels* (fig. 4). The former are denominated *Cellular plants* (fig. 14, p. 9), and they may be illustrated by mushrooms, moulds (fig. 5), sea-weeds, and lichens, which

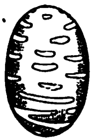


Fig. 6.


Fig. 7.

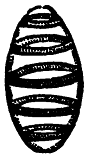


Fig. 8.

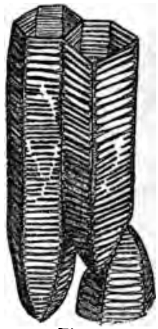


Fig. 9.

have no conspicuous flowers, and are reproduced by small cellular germs. The latter receive the name of *Vascular plants*, and are seen in the case of ordinary trees, shrubs, and herbs, which have more or less evident flowers, and are reproduced by true seeds (fig. 13, p. 7).

The structure of the cells and vessels of plants can

spawn or matrix *a*, whence the plant arises. Its stalk *b* is composed of cells or little bladders placed end to end, and at the summit are numerous bead-like bands *c*, consisting of minute microscopic germs (cellules).

Figs. 6 to 9.—Various forms of cells and vessels magnified. 6. Dotted cell, the marks being caused by pits or depressions on the wall of the cell. 7. Dotted or pitted vessel composed of united cells with the partitions obliterated. 8. Annular or ringed cell, with fibres in the form of rings. 9. Scalariform or ladder-like vessels of ferns. The marks are in the form of bars or lines, and the vessel is prismatic.

only be fully seen by the aid of the microscope. In some cells and vessels there are seen markings in the

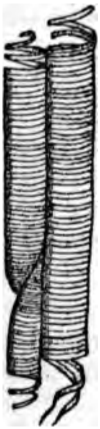


Fig. 11.

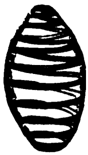


Fig. 10.

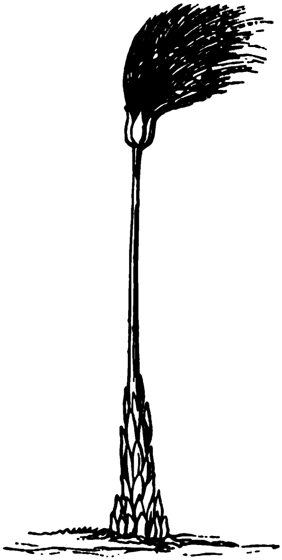


Fig. 12.

form of dots (figs. 6 and 7), or rings (fig. 8), or bars (fig. 9), or fibres, coiled up like a corkscrew (figs. 10 and 11). Hence arise the various names of dotted,

Fig. 10.—Spiral cell, with an elastic spiral fibre inside.

Fig. 11.—Spiral vessels, with spiral fibres inside, some unrolled.

Fig. 12.—*Papyrus antiquorum*, the bulrush of Scripture. It grows in the Nile, and is used for making light boats. In Lucan's *Pharsalia*, iv. 136, we meet with the following:—"Conseritur bibula Memphitis cymba Papyro." We may conclude that the ark in which the infant Moses was laid in the Nile—an ark of bulrushes, daubed with slime and with pitch—was a small boat constructed with papyrus. In Abyssinia, according to Bruce, boats are made of this plant. Another species, *P. syriacus*, grows in Sicily, and is used for paper.

annular or ringed, barred or ladder-like, and spiral cells and vessels. These, along with woody or bast tubes (fig. 4), may be seen in different parts of the same plant. Vessels called laticiferous, and woody tubes called punctated or disc-bearing, showing bordered pits, are described at pages 10 and 31.

Common mould (fig. 5) and mushrooms are composed of cells united together; so is the pith of trees, cotton, cork from the outer bark of the cork-oak, rice-paper, and the paper of the ancients, made from the papyrus —the bulrush of Scripture (fig. 12). All fleshy fruits, as the peach, and succulent roots, as turnip and carrot, contain a large quantity of cellular tissue; and the object of the horticulturist in many instances is to increase it, and thus to render vegetables tender and succulent, which would otherwise be tough and dry. Cells often become hardened and thickened by matter deposited within. Thus the hard shell of seeds, and the stone of fruits, consist of woody cells. The coverings of some seeds, as *Collomia*, exhibit spiral cells (fig. 10), the fibres of which, when moistened by water, uncoil in a remarkable manner, and form a beautiful object under the microscope. The use of this seems to be to fix the seeds in the moist soil after being scattered. Annular cells (fig. 8) are met with in Cactuses.

The woody parts of plants consist of elongated tubes, tapering to each end (fig. 4), and rendered tough by woody matter deposited within. These woody tubes can be separated from the bark and stems of many plants by maceration or steeping in water; and in this way hemp, flax, and bast are procured. Each minute thread

of these substances consists of numerous woody tubes overlying each other, as represented in fig. 4, and thus having considerable tenacity. Pitted or dotted vessels (fig. 7) are the largest kind of tubes in plants. They are well seen in the sugar-cane, in the bamboo,

Fig. 13.

and in the bramble. Spiral vessels are met with abundantly in the higher tribes of plants. They may be procured from common asparagus after being boiled, by separating the cellular portion in water under the simple microscope. The spiral fibres of the vessels may

Fig. 13.—Aerial stem of Banana (*Musa sapientum*), formed by sheathing leaves. The proper stem is subterranean, and the stem shown in the figure is a shoot sent up, bearing leaves and fruit, and then decaying to give place to another shoot. The cluster of fruit is seen at the top. The plant contains numerous spiral vessels.

be exhibited by making a superficial cut round the leaf-stalk of a geranium or strawberry, and then pulling the parts gently asunder. When the coil is unrolled, it appears like the threads of a cobweb. In the common hyacinth and lilies these spiral fibres can be easily seen. In the case of the banana (fig. 13), the spiral fibres are so abundant that they are pulled out and used as tinder in the West Indies. In the stem of trees the spiral vessels exist around the pith. In the common garden balsam several varieties of vessels exist, which can be readily separated under the microscope. Vessels, having bars arranged like the steps of a ladder (fig. 9), occur in ferns.

Thus all the parts of plants, including root, stem, leaves, flowers, and fruit, are composed of cells and vessels of different kinds, either separate or combined; and by means of these simple tissues the Creator carries on all the wondrous processes of vegetable life. The absorption of nourishing fluids takes place by the cells of the root; the sap then rises through the cells and vessels and intercellular canals of the stem; it reaches the cells and vessels of the leaf, and is there exposed to the action of air and light, so as to fit it for the various secretions given off as it descends through the cells and vessels of the bark. Thus the functions of nutrition or nourishment are accomplished. The cells and vessels of the flower, on the other hand, undergo changes, and are united in the form of various organs, so as to enable them to perform the functions of reproduction, and to produce the perfect seed.

To cells we trace all the phenomena of vegetable

life; they constitute the first tissue of all plants, and to them we must refer all the other tissues. In its embryo or youngest state, the plant consists entirely of cells. In their unchanged primitive condition cells

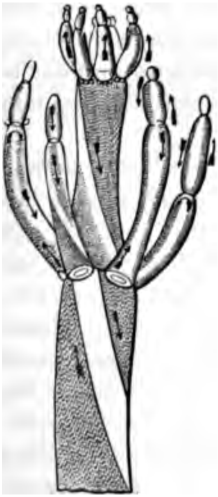


Fig. 14.

a Fig. 15. *b*

are seen in cellular plants, and in the pith, the pulp, and the succulent parts of vascular plants. When thickened by hard deposits inside they form the woody cells of the stones of fruits, and when elongated they

Fig. 14.—A small portion of a Chara magnified to show the intra-cellular circulation. The arrows mark the direction of the fluid and granules in the different cells. The clear spaces are parts where there is no movement. The circulation in each cell is independent of that in the others.

Fig. 15.—*Vallisneria spiralis*, an aquatic plant, found in ditches in the south of Europe (much reduced in size). In the separate cells movements of fluids take place. *a*, Stamen-bearing plant; *b*, pistil-bearing plant.

appear as the fibres of the wood, giving firmness to the stems and to the ribs of the leaves; and when lined with a spiral thread, they appear as spiral cells and vessels of various kinds. Cells also contain in their interior a gelatinous substance, called *protoplasm*, and *nuclei* (fig. 3, p. 3), both of which are concerned in the production of new cells and in the movements within the *cell-wall;* cells have also the power of dividing into two, and thus multiplying.

Besides a general movement of sap, there are also special movements occurring in cells and vessels. In the cells of aquatic plants, such as *Chara* (fig. 14) and *Vallisneria* (fig. 15), there is a distinct and regular motion of granules, which is easily seen under the microscope. These movements are promoted by moderate heat, and seem to take place in a spiral manner round the cells. They appear to be connected with the life of the individual cell, and the formation of new cells. In the jointed hairs seen in the flowers of the Virginian spider-wort, and in the hairs of the common nettle, similar motions are observed. In certain vessels of plants, called *laticiferous*, movements of granular matter have been detected. These vessels, or intercellular canals, according to some, have a peculiar structure, and unite together freely, as seen in fig. 16, so as to form a sort of network. They are best seen in plants with milky or coloured juices, as the India-rubber and Gutta-percha plants, Spurges (*Euphorbia*), and Celandine (*Chelidonium*). Some consider the motions in these vessels as being connected with the return of the sap from the leaves to the bark.

Cells contain various kinds of fluids—some coloured, others colourless; some thin, others thick and viscid. They also contain starch (fig. 17), sugar, wax, fatty and oily matters, air, and crystals which are called needles

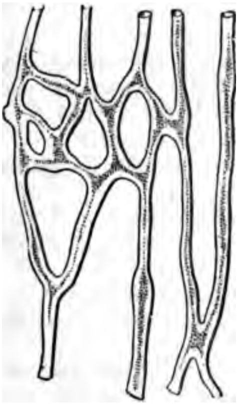


Fig. 16.

Fig. 17.

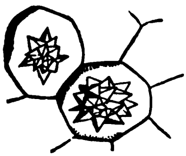


Fig. 19.

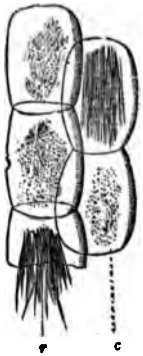


Fig. 18.

(raphides, fig. 18). These crystals consist usually of lime in combination with oxalic or phosphoric acid. They are easily seen in the common hyacinth and in other plants belonging to the lily tribe; also in Balsams, Willow-herbs, and Galiums. Their presence or absence is a mark of distinction in some families of plants. Conglomerate crystals are seen in the cells of Beet-root (fig. 19).

Fig. 16.—Laticiferous vessels (sometimes called milk-vessels or canals) of the common Dandelion. The vessels unite together freely, and movements of granular matter take place in them.

Fig. 17.—*a*, Starch-cells of the pea, showing grains of starch in the interior. *b*, Separate starch grains with striæ (lines).

Fig. 18.—Cells of Dock *c*, containing raphides *r*. The cells are called Raphidian. The raphides consist of needle-like crystals joined together in clusters.

Fig. 19.—Cells of Beet-root, containing conglomerate crystals.

QUESTIONS.

1. What is meant by the organs of plants?
2. Mention the nutritive organs of plants.
3. Mention the reproductive organs of plants.
4. What does the minute structure of plants consist of?
5. Describe a cell.
6. Describe a vessel.
7. What is meant by cellular plants? Give an example.
8. What is meant by vascular plants? Give an example.
9. How are dotted cells and dotted vessels formed?
10. How are annular cells and vessels formed?
11. Describe scalariform vessels, and mention the plants in which they occur.
12. How are spiral cells and vessels formed?
13. What is the form of the tubes and bast-cells which constitute the wood of trees?
14. Of what tissue is the pith of plants composed?
15. What is the structure of cork, and whence is cork procured?
16. What is the structure of rice paper and papyrus paper, and how do they differ from common paper?
17. What tissue abounds in fleshy fruits and in fleshy roots?
18. What is the structure of the shell in stone-fruits, such as the peach?
19. What is the structure of flax and hemp?
20. In what part of the stem of trees do spiral vessels chiefly occur?
21. What are the functions performed by cells and vessels?
22. Of what tissue does the young plant consist in its earliest state?
23. Describe the movements seen in the interior of some cells, and mention the plants in which they are seen.
24. What movements are seen in vessels? Mention the vessels in which they are seen.
25. Mention some of the contents of cells.
26. What is protoplasm?
27. What are raphides, and of what are they composed?

II.—On the Structure, Conformation, and Functions of the Root.

The root is the first part of the young plant which protrudes from the seed (fig. 20 *r*). It descends into

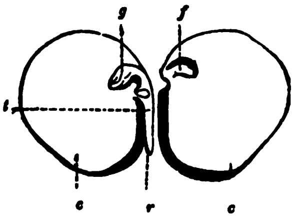


Fig. 20.

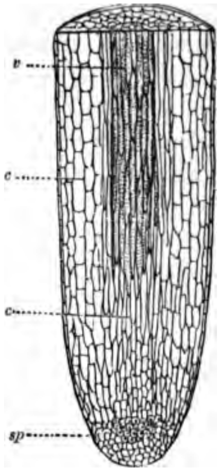


Fig. 21.

the ground in order to fix the plant and to imbibe nourishment. On account of its downward tendency, the name of Descending Axis is sometimes applied to

Fig. 20.—Embryo of the pea (*Pisum sativum*). The cotyledons *c c*, or seed-lobes, are fleshy, and remain below ground. The radicle *r* protrudes through an opening, and is the first portion of the embryo which appears during germination. The plumule, gemmule, or first bud, *g*, afterwards appears and rises upwards to form the ascending axis. The common axis *t*, whence the radicle and plumule proceed, is united to the cotyledons by a short petiole; *f*, a small depression in one cotyledon, where the young bud *g* lay.

Fig 21.—Vertical section of a rootlet of an Orchis, much magnified; *sp*, the minute cells at the extremity, called spongioles or spongelets; *c c*, the other cells of the root; *v*, dotted vessels.

it. The cells situated near the extremities of the minute fibrils of the root are those which are chiefly concerned in taking up nourishment from the soil. They are sometimes called spongioles (fig. 1). One of them is represented on a magnified scale in fig. 21, *sp*. The other cells of the root are indicated by *c c*, and these pass gradually into dotted vessels *v*.

Some roots taper as in the carrot and radish, and are called tap-roots (figs. 23, 24); others branch in various ways (fig. 22). In grasses we see frequently numerous fibrils proceeding from one point, and giving rise to fibrous roots (fig. 26.) In the turnip the root is large and succulent (fig. 25).

As plants are fixed to a spot, their food must be always within reach; and it is requisite that the roots should have the power of spreading, so as to secure renewed supplies of nutriment. A beautiful provision is made for this by the elongation of the roots taking place at their extremities, so that their advancing points are enabled easily to accommodate themselves to the nature of the soil in which the plant grows. They are thus also enabled to move easily from one part of the soil to another, according as the nourishment is exhausted. The exhaustion of the soil by the roots of plants affords an explanation of the phenomenon called *fairy rings*, consisting of circles of toadstools, followed by dark-green grass, seen in old pastures. These have been traced to successive generations of certain fungi spreading from a central point, and absorbing the nutriment of the soil, so as to unfit it for the growth of the fungi, but not for the growth of grass.

The root, in its growth, keeps pace with the develop-

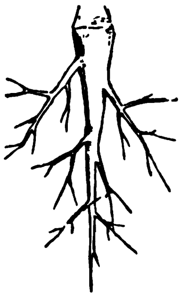


Fig. 22.

Fig. 23.

Fig. 24.

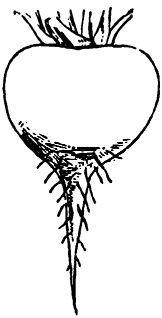


Fig. 25.

Fig. 26.

ment of the stem and its branches. As the stem shoots

Figs. 22 to 26.—Various forms of root. 22. Branching root of Mallow. 23. Conical tap-root of Bryony. 24. Spindle-shaped tap-root of Radish. 25. Succulent root of Turnip. 26. Fibrous root of Rib-grass. In figs. 23 to 26 the crown of the root is seen, which is a shortened stem bearing leaves.

upwards and produces its leaves, from which water is constantly transpired, the roots continue to spread, and to renew the delicate cells and fibrils which absorb the fluid required to compensate for that lost by evaporation, or consumed in growth. There is a constant relation between the horizontal extension of the branches and the lateral spreading of the roots. In this way the rain which falls on a tree drops from the branches on that part of the soil which is situated immediately above the absorbing fibrils of the roots. If the roots are not allowed to extend freely, they exhaust the soil around them, and do not receive a sufficient supply of food. The plants in such a case, deprived of their proper means of support, become stunted and deformed in their appearance.

If we wish trees to be firmly rooted, we must allow the branches to spread freely. When they are so planted that the branches and leaves of contiguous trees do not interfere with each other, and all parts are exposed to air and light equally, the roots spread vigorously and extensively, so as to fix the plants firmly in the soil, and to draw up copious supplies of nourishment. But in crowded plantations, where the branches are not allowed freedom of growth and exposure, and the leaf-buds are consequently either arrested or feebly developed, the roots also are of necessity injured. They do not spread, and the trees are liable to be blown over by the wind; they exhaust the soil in their vicinity, circumscribed by the roots of the trees around; their functions become languid, and thus they react on the stem and branches, so that the additions to the wood are small, and the timber

is of bad quality. In such a plantation, we may see a marked difference between the trees on the outside and those in the centre ; the former, having their branches and leaves fully exposed on one side, grow with comparative vigour, and form excellent timber on that side of the stem where light and air are admitted ; while the latter, hemmed in on all sides, are *drawn up* like bare

Fig. 27.

poles, producing a small amount of ill-conditioned wood. A crowded plantation, in which the trees are allowed to increase in size, until they interfere with each other, cannot be easily reclaimed ; and any attempt at thinning is accompanied with the risk of exposure to the blasts, which speedily level trees having no firm hold of the soil.

Roots in general descend into the soil at once ; but in some cases they proceed from different parts of the stem, and thus are in the first instance aerial. The

Fig. 27.—*Ficus indica*, the Banyan-tree (belonging to the same genus as the Fig.), sending out numerous adventitious or aerial roots, which reach the soil, and prop the branches.

Banyan-tree of India (fig. 27) exhibits these roots in a remarkable manner. They proceed from all parts of its stem and branches, and ultimately reach the soil, forming numerous stem-like roots which support this wide-spreading tree. The famous Nerbudda Banyan had 300 large and 3000 small stems, and was said to be capable of sheltering 7000 men.

Fig. 28.

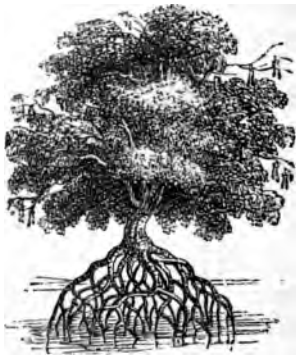


Fig. 29.

"Such, too, the Indian fig, that built itself
Into a sylvan temple, arch'd aloof
With airy aisles and living colonnades."—MONTGOMERY.

Or, as Milton describes it :—

"The fig tree ; not that kind for fruit renowned ;
But such as at this day to Indians known
In Malabar and Deccan, spreads her arms,
Branching so broad and long, that in the ground
The bending twigs take root, and daughters grow
About the mother-tree, a pillar'd shade,
High over-arched, with echoing walks between."

Fig. 28.—*Pandanus odoratissimus*, the Screw pine, giving off numerous aerial roots near the base of its stem.

Fig. 29.—*Rhizophora Mangle*, the Mangrove-tree, supported, as it were, upon piles by its numerous roots, which raise up the stem.

In some parts of India bridges are made by uniting the aerial roots of species of Ficus, growing on either side of a stream.

The Screw pine (fig. 28) is another instance of a plant giving out aerial roots. These support the plant like wooden props. The Mangrove (fig. 29) also exhibits similar supports.

Fig. 30.

Fig. 31.

When roots do not extend much, they are sometimes provided with reservoirs of nourishment which supply the means of growth during a certain period. This is seen in the case of terrestrial orchids (figs. 30, 31). These reservoirs or tubercules constitute the salep of commerce, which is used as food. In dry soils, roots are sometimes unable to spread from want of moisture, and

Fig. 30.—Roots of Orchis; some of them are slender and absorb nutriment, while two of them are thick, fleshy tubercules, which contain a reservoir of food, and constitute salep.

Fig. 31.—Orchis, showing tubercles or tuberous roots, which contain nourishing matter.

form bulb-like appendages so as to lay up a store of nourishment. In seasons of drought also, a similar occurrence may take place. In the orchids of warm climates, in place of thickened roots there are large bulb-like stems which serve the same purpose (fig. 32). These orchids, which are often called air-plants (epiphytes), send out roots into the air, and attach them-

Fig. 32.

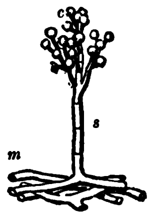


Fig. 33.

selves to the stems and branches of trees. They do not push their roots into the interior of the plants, but they are nourished by the moisture around them, and by the decay of matter on the outside of the branches. Some plants send their roots or suckers into the substance of other plants either dead or living, and derive their food entirely from them. Such are

Fig. 32.—Orchideous air-plant, with its peculiar flowers and bulb-like stems.

Fig. 33.—A species of mould-fungus (*Botrytis*), magnified. There are below root-like filaments *m*, constituting the spawn. These insinuate themselves into the tissues of living plants, and act as parasites, drawing nourishment from the tissues, and ultimately destroying the plants. The stalk *s* consists of cells bearing rounded reproductive cells or spores *c*.

called *parasites*, and they may be illustrated by moulds (fig. 33); by fungi which grow on the decaying stumps of trees, and by those which cause diseases in growing crops; by dodder (fig. 34), which injures flax and clover

Fig. 34.

by living on their juices; and by broom-rapes, scalewort, and the gigantic Rafflesia of Sumatra and Java (fig. 35). Some of these parasites have no leaves (dodders); others bear whitish or brown scales (scalewort and broom-rape);

Fig. 34.—Cuscuta or Dodder, a parasite which first grows in the usual way, from seed, with its roots in the ground, but ultimately twines round other plants, and becomes attached to them by means of the rounded suckers represented on the slender branch *a* in the figure. The Dodder loses its connection with the soil.

while others, as the mistleto (fig. 36), have green leaves, which elaborate the juices derived from the stock by

Fig. 35.

exposing them to the air and light. The study of the growth of parasitic fungi is a subject of great import-

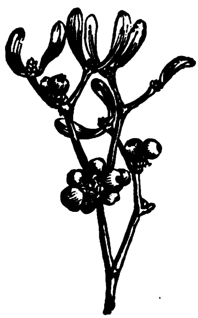


Fig. 36.

ance, as many diseases in plants, animals, and man, appear to be either caused or modified by them. Dry-rot in wood, for instance, is attributed to the attack of a

Fig. 35.—*Rafflesia Arnoldi*, a parasitic plant of Sumatra and Java. The flower is three feet in diameter. It grows attached to the stem of a climbing Cissus.

Fig. 36.—*Viscum album*, the Mistleto, a green-leaved parasite which derives nourishment from the plants to which it is attached.

fungus; so also are certain diseases of the skin and mucous membrane in man and animals.

QUESTIONS.

1. Why is the root called the descending axis?
2. What is meant by fibrils of the root?
3. What is meant by spongioles, and where are they seen? What is the crown of the root?
4. What is meant by a tap-root? Give an example.
5. In what manner do roots lengthen?
6. Give an explanation of fairy-rings.
7. What is the function of roots?
8. What relation do roots bear to branches?
9. Describe the injury caused by plantations being crowded.
10. What is meant by aerial roots? Give examples.
11. What kind of roots are met with in Orchids?
12. What is salep?
13. What is meant by epiphytes? Give an example.
14. What is meant by parasites? Give examples.
15. Describe four kinds of parasites.
16. How is dry-rot in wood produced?

III.—On the Structure, Conformation, and Functions of the Stem.

The stem is the name given to that part of a plant which bears the leaves and the flowers. Some plants have very short and inconspicuous stems; others have long and conspicuous stems. In the cowslip, dandelion, and gentianella, the stem is so short that the leaves appear to rise from the root, and are hence called radical leaves. Some stems lie along the ground only partially covered by soil, as the iris and Solomon's seal (fig. 37); others are completely under ground, as ginger (fig. 38).

The latter give off leaf-buds, which appear above ground. The banana (fig. 13, p. 7) has an underground stem pushing out shoots, which form temporary aerial stems or branches; so have also the asparagus, the bamboo, arrow-root, and some rushes and sedges. Many subterranean stems are called, in common language, roots,

Fig. 37.

Fig. 38.

from which, however, they are distinguished by the leaf-buds which spring from them. Thus the potato is an underground stem or branch giving off buds in the form of *eyes.* The bulbs of lilies, leeks (fig. 39), and tulips, with their fleshy scales, and the more solid bulb-like corms of crocuses and meadow-saffron (fig. 40), are in reality stems giving off buds, which are covered with different kinds of scales or modified leaves. The

Fig. 37.—Rhizome, root-stock, or partially subterranean creeping stem of Solomon's seal (*Polygonatum multiflorum*). The scars left on the stem by the fall of the buds give rise to the English name of the plant.

Fig. 38.—Rhizome, or thickened creeping stem of ginger (*Zingiber officinale*), producing flowering stems and roots. This rhizome or root-stock is the part used economically and medicinally, and called ginger-root.

cloves of onions are the young buds formed at the points

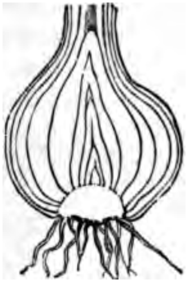


Fig. 39.

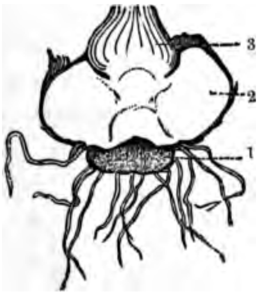


Fig. 40.

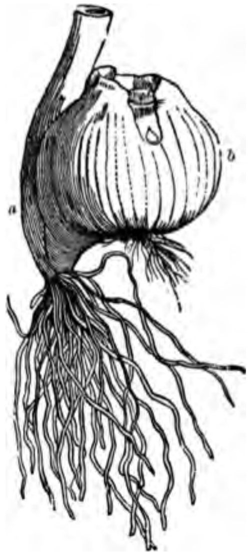


Fig. 41.

where the fleshy scales join the underground stem. The

Fig. 39.—Bulb of leek (*Allium Porrum*), cut perpendicularly, showing the disc at the base whence roots proceed on one side, and scales with the growing point on the other. The outside scales are thin and dry, while the internal ones are thick and fleshy.

Fig. 40.—Corm of the Saffron (*Crocus sativas*), showing the mode in which new corms are produced above the old. It may be looked upon as a rhizome, increasing vertically in place of horizontally. No. 1 indicates the old corm now shrivelled; 2, the corm produced at the apex of it, in the form of a bud; 3, the young bud producing a flowering stem.

Fig. 41.—Corms of Meadow-saffron (*Colchicum autumnale*); *a*, old corm shrivelling; *b*, young corm produced laterally from the old one. Leaf-buds are produced at the upper part; roots below.

new buds of the crocus and gladiolus are produced at the summit of old underground corms (fig. 40), while those of the meadow-saffron are formed at the side of the

Fig. 42.

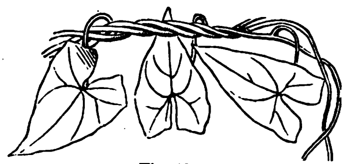


Fig. 43.

corms (fig. 41). In these cases the new corm feeds upon the old one, and gradually absorbs its contents.

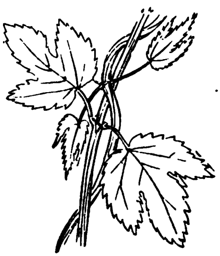


Fig. 44.

Some stems are weak, and are supported by climbing on walls or rocks, as ivy (fig. 42), or by twining round some support, as convolvulus (fig. 43). These twining

Fig. 42.—Branch of Ivy (*Hedera Helix*), with root-like processes, by means of which it is attached to walls or trees.

Fig. 43.—Stem of Bindweed (*Convolvulus sepium*) twining from right to left.

Fig. 44.—Stem of Hop (*Humulus Lupulus*), twining from left to right.

stems turn in certain definite directions. Thus the convolvulus (fig. 43), passion-flower, and French bean, twine from right to left, that is, to a person supposed to be in the centre of the coil, and the stem passing across his chest from his right to his left; while the hop (fig. 44), honeysuckle, and black bryony, twine from left to right.

Exogenous or Dicotyledonous Stem.—Some stems die annually, others continue permanent. In flowering plants there are two marked kinds of stems. One occurs

Fig. 45.

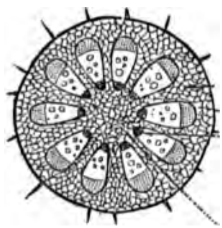


Fig. 46.

in the trees of temperate climates generally, and is recognised on a transverse section by the appearance of numerous woody circles with rays passing from the pith to the bark which is separable. This is well seen in the

Fig. 45.—Transverse section of the stem of an oak six years old —*i.e.*, having six concentric woody circles; cellular pith in the centre, surrounded by spiral vessels, and woody layers consisting of woody tubes and porous or pitted vessels, layers of bark, both cellular and fibrous, on the outside.

Fig. 46.—Section of an Exogen during its first year of growth; *m* cellular pith, very large and occupying a considerable part of the stem; *t* spiral vessels forming a layer round the pith; *r* large cellular rays joining the pith and bark, which is represented by cells on the circumference. The woody and pitted vessels are placed between the pith and the bark, and are divided in ten wedges by the rays.

common oak (fig. 45), where the pith in the centre is composed of cells; the circles of wood consist of fibrous vessels (fig. 4, p. 3), and dotted or pitted vessels

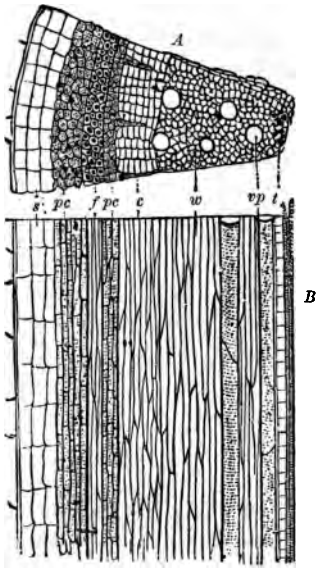


Fig. 47.

(fig. 7, p. 4); cellular rays extend from the pith to the bark—the latter being partly fibrous and partly cellular. A section of such a stem in the first year of growth exhibits the appearance presented in fig. 46, where *m* is

Fig. 47.—Stem of a maple at the commencement of its second year of growth. *A* transverse or horizontal section; *B* longitudinal or perpendicular section; *t* spiral vessels round the pith; *vp* porous or pitted vessels with large apertures; *w* fibrous vessel of wood; *c* layer of sap-wood between bark and heart-wood; *pc*, *pc*, inner cellular portion of bark separated by fibrous vessels (bast) of the bark *f*; *s* outer cellular corky layer of bark.

the cellular pith, very large; *r* large cellular rays proceeding from the pith and ending in the cellular bark, which forms the circumference. These rays divide the stem in the figure into ten wedges of woody and pitted vessels; while spiral vessels *t* occur round the pith. In the second year of growth a second set of vascular wedges is formed outside the first circle, and so on year after

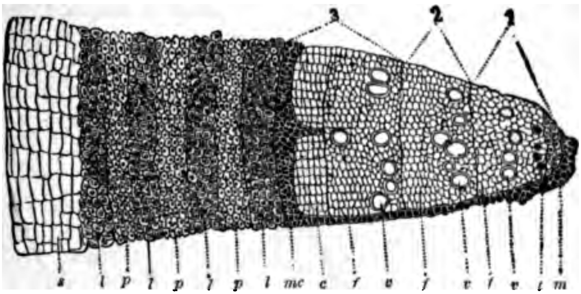


Fig. 48.

year, the stem increasing in diameter by circles of wood on the outside of those previously formed. The new wood is on the outside, the old wood within. Such trees are hence called Outward-growers or *Exogens*, and they have their hard wood in the inside, their soft wood on the outside. The trees are all called Dicotyledonous because they have two seed-leaves or seed-lobes. (See under *Embryo.*)

The structure of the different parts of such a stem

Fig. 48.—Transverse section of a maple three years old—1, 2, 3, being the woody growth of each year, the layers of bark extending from *s* to *mc*. The pith is marked *m*; spiral vessels *t*; porous, dotted, or pitted vessels *v*; fibrous vessels *f*; layer of new wood *c*; layer of new bark-cells *mc*; inner fibres of bark *l*; cellular layer of bark *p*; outer corky bark *s*.

is represented in fig. 47, where *A* is a transverse section, and *B* is a longitudinal one, of the stem of a maple one year old. In these figures, *t* indicates the spiral vessels (fig. 11, p. 5) round the cellular pith; *vp* are pitted vessels (fig. 7, p. 4), showing large round apertures; *w* fibrous vessels (fig. 4, p. 3); *c* a layer of new wood or alburnum next to the bark, which is composed of cells *s* and *pc*, and of fibres *f*. A stem of maple, three years old, is given in fig. 48. Taking the woody part

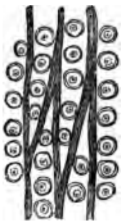


Fig. 49.

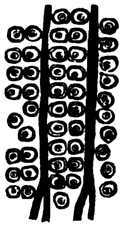


Fig. 50.

Fig. 51.

of the stem, we find that during the first year (1) there is the cellular pith *m*; spiral vessels *t*; porous, dotted, or pitted vessels *v*; and fibrous vessels *f*. In the second year (2) there are seen dotted vessels *v*, and fibrous vessels *f*. So also in the third year (3). A layer of new wood below the bark is marked *c*. The outer bark, sometimes of a corky nature, as in the cork-oak (fig. 54), is marked *s*; and below it are different layers of bark, composed of fibrous vessels *l*, and cells *p*; while, next

Fig. 49.—Woody tubes of fir, with single rows of discs or bordered pits formed by depressions on the walls of the vessels. Fig. 50.—Woody tubes of fir, with double rows of discs or pits which are opposite to each other. Fig. 51.—Woody tubes of *Araucaria excelsa*, with double and triple rows of bordered pits, which are alternate.

the newest wood, or sapwood, *c*, there is a cellular layer connected with the bark, marked *mc.* This cellular layer, *c*, is called *cambium*, and consists of active cells which are concerned in the formation of new wood and bark.

The woody tubes in cone-bearing trees, as fir, spruce, larch, cedar, cypress, and Araucaria, exhibit markings

Fig. 52.

called discs or punctations, which appear in the form of a circle and a dot in the centre. These so-called punctations are formed by depressions on the walls of the vessels, and are called bordered pits. Sometimes these bordered pits are in single rows, as in fig. 49 ; in others they are in double or triple rows, as in figs. 50 and 51. When the rows are more than one, they are arranged in parallel series, the bordered pits being either opposite to

Fig. 52.—*Araucaria* (*Eutassa*) *excelsa*, Norfolk Island pine.

each other, as in Firs (fig. 50), or alternate with each other, as in Araucaria and Norfolk Island Pine (fig. 51). The latter plant is represented in fig. 52, and is interesting on account of the markings in its wood, as well as from the fact that plants allied to it have been found in Britain in a fossil state — for instance, at Craigleith and Granton quarries near Edinburgh.

From the mode of growth in exogenous trees, it is obvious that we can ascertain the age of the tree by counting the number of woody circles or zones. Thus in fig. 45, p. 27, the oak is six years old. This calculation can be made with tolerable correctness in trees of temperate and cold climates, where during the winter there is a marked interruption to growth, and thus a line of demarcation is formed between the circles. In trees of warm climates this mode of estimating age may lead to error, for it would appear that in them there is often the appearance of two or more circles in one year. Even in the trees of this country, when full-grown, it is found that the different circles are so blended as to make it difficult to count them accurately.

The wood in the centre of exogens is often altered in colour by variously-coloured woody matter being deposited in the tubes. Thus the heart-wood (*duramen*) of the ebony-tree is black, and that of the oak deep brown, while that of the outer soft wood (*alburnum*) is pale. The latter is the part in which the active processes of life go on; and hence, if it is destroyed, the plant dies. A woody plant, such as honeysuckle, and some Bauhinias of foreign countries, twining round the stems of such trees, cause strangulation, in consequence

of the mode of their growth by external additions; and in process of time, if the woody climber is sufficiently strong, and does not break or yield, the vessels of the soft wood or sap-wood are impeded in their growth, and the tree will ultimately be destroyed. In fig. 53, a twining plant, called the *bush-rope* in the West Indies, is seen causing contractions of the stem.

Fig. 53.

Fig. 54.

Sometimes grooved sticks are formed in the same way in Britain, by the twining of the honeysuckle round neighbouring trees.

The size attained by the stems of many exogens, both as regards height and diameter, is sometimes very great. Trees belonging to the cone-bearing tribe attain

Fig. 53.—The effects of a twining plant on an exogenous stem. The Bush-rope, a climbing-plant, twining round the stem of an Exogen, and causing strangulation.

Fig. 54.—Cork-oak (*Quercus Suber*), a dicotyledonous tree of the warmer temperate zone. Its outer layer of bark supplies cork.

heights varying from 100 to 200 feet. The oak sometimes attains the height of 120 feet; and forest trees on the Continent and in America are met with 150 feet high. The celebrated mammoth pine of Oregon (*Sequoia* (*Wellingtonia*) *gigantea*) has been seen 450 feet high. Some cedars of Lebanon have a girth of 40 feet, chestnuts occasionally attain to 60 feet, the baobab tree of Senegal has been measured 90 feet in

Fig. 55.

circumference (fig. 55), and the Wellingtonia nearly 120 feet.

Exogenous trees give a character to the landscape of the countries in which they abound. They have large trunks, which produce numerous branches, spreading in all directions. The trunk tapers as it ascends, and the branches become thinner towards their extremities. The mode in which the branehes spread, and their comparative lengths, give rise to differences

Fig. 55.—Baobab-tree (*Adansonia digitata*) of Western Africa, having a stem 90 feet in circumference.

in the contour of exogenous trees. When the lower branches are largest, and the others gradually diminish in length upwards, the trees are more or less pyramidal, as in the Douglas pine (*Abies Douglasii*); when the reverse takes place, they have an umbrella-like top, as in the Stone pine (*Pinus pinea*). The poplar furnishes

Fig. 56.

an example of a tree whose branches come off at acute angles with the trunk. The cedar of Lebanon (fig. 56) will serve as an illustration of an exogenous tree with branches spreading at right angles to the truuk.

Fig. 56.—The Cedar of Lebanon (*Cedrus Libani*), an exogenous tree, with a thick trunk and spreading branches.

QUESTIONS.

1. Describe the stem or ascending axis.
2. Are stems always erect ?
3. What is the essential character of a stem ?
4. Describe the stem of the Iris.
5. What kind of stem has the ginger plant ?
6. Describe the stem of asparagus.
7. To what part of the plant is the edible potato referred ?
8. What is meant by the eyes of the potato ?
9. Describe a bulb as seen in the lily and the onion.
10. What is meant by the cloves of an onion ?
11. What is meant by a rhizome or root-stock ? Give an example.
12. What is meant by a corm ? Give an example.
13. Describe the formation of buds in the crocus and in the meadow-saffron.
14. How do stems twine ? Give examples of different kinds of twining.
15. What is meant by annual stems ?
16. What is meant by the term exogenous ?
17. Mention the parts of an exogenous stem proceeding from the centre to the circumference.
18. Give the structure of the different parts of an exogenous stem.
19. Give another name for exogens.
20. Mention a peculiarity in the wood of the fir-tree and of the Araucaria.
21. How is the age of an exogen determined ?
22. What is meant by the duramen and the alburnum of an exogenous tree ?
23. What part of the ebony-tree is used for furniture ?
24. Describe the effect of a twining woody plant, such as the honeysuckle, on the stem of an exogen.
25. Mention some exogens remarkable for the height and diameter of their stems.
26. In what manner do branches spread in the poplar, and in the cedar of Lebanon ?

Endogenous or Monocotyledonous Stem.—Another marked type of stem occurs in some herbaceous plants, such as lilies and grasses, and is well seen in palms, dracænas, and trees of warm climates. In palms the increase of growth is by additions of woody and pitted vessels towards the centre. The stem is at first entirely cellular, but in the progress of growth bundles of vessels are formed among the cells. These gradually increase and distend the stem to a certain amount the first year. Next year new bundles are produced inside

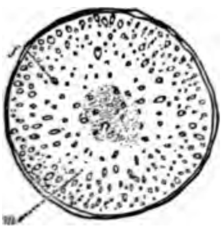


Fig. 57.

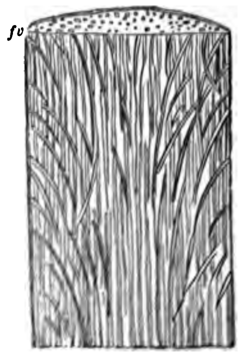


Fig. 58.

the last, which increase the diameter still more, until at length, by successive additions, the stem is distended to the utmost. The outer portion becomes hard, so as sometimes to resist the blow of a hatchet, while the inner part is comparatively soft. This mode of growth

Fig. 57.—Transverse section of a palm-stem, showing endogenous structure. Cellular tissue m; bundles of woody and other vessels f. No concentric circles, no rays.

Fig. 58.—Longitudinal section of a palm-stem. Fibrous vessels fv, descending in an oblique manner, and interlacing.

has given rise to the name of Inward-growers or *Endogens*, applied to plants having stems of this kind. The plants are also called monocotyledonous because they have only one seed-leaf or seed-lobe. On making a transverse section of a palm-stem, the appearance presented is seen in fig. 57. There is no distinct pith, no concentric circles, no rays, no separable bark. The outer part representing the bark is hard, and is incorporated with the fibrous tissue below. The interior consists of cells *m*, in which bundles of vessels *f*, are disposed irregularly. In tracing the vessels *fv*, in the vertical section of a palm (fig. 58), it is found that they follow a curved course, and interlace with each other. Palms have straight trunks of nearly equal diameter throughout, bearing a cluster of leaves at the summit. This character is seen in figs. 60 and 61. They rarely branch, and grow chiefly in height, not much in diameter. The age of a palm may be estimated by measuring its height, for it is found that the growth in an upward direction is nearly uniform in each species. From the small increase in diameter, and the hardness of the exterior, a twining woody plant does not injure a palm-stem. In fig. 59 is seen a palm-stem with a woody bauhinia twisting round it, without affecting its growth. When the tuft of leaves at the summit of a palm is com-

Fig. 59.

Fig. 59.—A Bauhinia, or woody climber, twining round the stem of an endogen (Palm) and not causing any strangulation.

pletely destroyed, the plant dies, because there is no provision for lateral buds, as in the trees of Britain.

Palms give a marked and distinctive character to the vegetation of tropical regions, and their umbrageous foliage, particularly in the case of those with fan-shaped leaves, affords an excellent shelter from the sun's rays.

Fig. 60.

Fig. 61.

In figs. 60 and 61 are represented the Talipot palm of the East Indies, and the Date palm of Egypt. In them we remark the erect growth, the bare unbranched stem of nearly uniform diameter throughout, and the

Fig. 60.—*Corypha umbraculifera*, the Talipot palm. It has large fan-shaped leaves. Its clusters of flowers proceed in an erect manner from the summit of the stem.

Fig. 61.—*Phœnix dactylifera*, the Date palm, the Tamar of Scripture. Its leaves are compound and pinnate. The leaves are often called branches in ordinary language.

crown of leaves at the summit, from which the flowering stems and fruit proceed.

Fig. 62.

Acrogenous or Acotyledonous Stem.—Another conspicuous permanent stem is that which occurs in ferns, especially in the tree-ferns of New Zealand, and of tropical countries (fig. 62). In these plants the stem is uniform in its diameter, hollow, and marked on the outside by the scars of the leaves (fig. 63). It is often called a *Stipe.*

The vascular bundles are formed simultaneously, and not progressively, as in the stems already noticed; and additions are made in an upward direction. The stem is formed by additions to the summit and by the elongation of vessels already formed; and hence the plants are called Summit-growers or *Acrogens.* From the summit

Fig. 62.—East Indian Tree-fern (*Alsophila perrotetiana*). It has an acrogenous stem. The stem or stipe is unbranched. To-

of the stem are produced elegant clusters of feathery leaves. There is a continuous woody cylinder in the fern-stem. The vascular bundles unite and separate so as to form meshes; vessels pass from these bundles to the fronds, and also into abnormal roots, which are often produced abundantly on the outside of the stipe (fig. 62, *ra*). On making a transverse

Fig. 63.

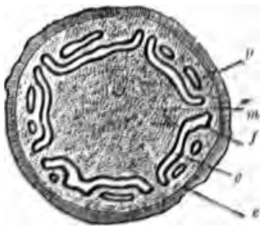


Fig. 64.

section of such a stem, the appearances seen are represented in fig. 64, where *e* is the outer portion, marked by the scars of fallen leaves, *f v* bundles of vessels forming an irregular cylinder, dark outside, pale in the

wards the base *ra* there is an obvious enlargement caused by a number of adventitious or aerial roots which cover the stem, and are applied closely to it.

Fig. 63.—Stem of a tree-fern. It is acrogenous or increases at the top. The stem is uniform in diameter, marked by scars of fallen leaves *c*.

Fig. 64. Transverse section of the stem of a tree-fern, showing the cellular portions *p m*, the irregular bundles of vessels forming the vascular cylinder *f v*, and the outer portions *e*.

centre, *p* outer layer of cellular tissue, *m* central cells, which are usually absorbed so as to leave a cavity. In the common brake or bracken of our pastures, the lower part of the stem, when cut, exhibits bundles of vessels which have the form of an oak or of a double spread-eagle. Fern stems occasionally divide dichotomously by the formation of two buds at their growing point. Ferns characterise mild and moist climates, and they give a peculiar feature to the landscape of New Zealand. At former epochs of the earth's history, they appear to have constituted a large part of its vegetation.

We have thus seen the structure of the three marked forms of permanent woody stems which are met with in the vegetable world :—1. Exogenous or Outward-growers (Dicotyledons), consisting of pith, concentric circles of wood, which increase by additions on the outside, separable bark, and rays connecting pith and bark; exemplified in the forest trees of Britain. 2. Endogenous or Inward-growers (Monocotyledons), consisting of a mass of cellular tissue with bundles of woody and other vessels scattered irregularly through the tissue, increasing by additions inside; exemplified in palms. 3. Acrogenous or Summit-growers (Acotyledons), formed by simultaneous vascular bundles which increase in an upward direction, additions being thus made to the summit, bundles of vessels irregular; exemplified in tree-ferns.

QUESTIONS.

1. Describe the structure of an endogenous stem, and give an example.
2. Why are some plants called Endogens?

3. Give another name for Endogens.

4. Which is the hardest part of the stem of a palm ?

5. In what respect does an endogenous differ from an exogenous tree as regards structure and aspect ?

6. Contrast the effect produced by a woody twiner on an Exogen and on an Endogen, and explain the cause of the difference.

7. Describe the structure of an acrogenous stem, and give an example.

8. Why is a stem called acrogenous ?

9. Give another name for Acrogens.

10. What is meant by the term Stipe ?

11. Contrast an endogenous and acrogenous stem as regards structure and appearance.

Buds and Branches.—Stems produce buds, which are developed as leaves or as branches bearing leaves. Buds may thus be regarded as shortened leaf-bearing axes, capable of elongation so as to form stems and branches. Some buds are terminal (fig. 65, *a*), or are produced at the extremity of the primary axis. Other buds are lateral, or are produced at the sides of the axis (fig. 65, *b*). Exogenous stems have the power of forming both lateral and terminal buds, and if the terminal bud is destroyed, the functions of the plant are carried on by lateral buds, as in pollard trees. In palms and tree-ferns, the buds are terminal, and in their case when the top of the stem is cut off the plants perish. In some of them we find two in place of one terminal bud, and then the stem divides in a

a

b

b

Fig. 65.—Branch ending in a terminal bud, *a*, covered with protecting scales. Lateral buds are seen at *b b*, produced in the axil of leaves which have fallen and left scars.

forking (dichotomous) manner, as seen in the Doom Palm of Egypt. Buds are often protected by coarse leaves or scales (fig. 65, *a*) which are arranged spirally, and are occasionally covered with resinous or gummy matter for protection. Branches are connected with the centre of the woody stem. They occur especially in Exogens, and they have the same structure as the stems whence they proceed. Branches are arranged on the stem in a spiral manner, and follow the same law of spiral symmetry as will be noticed in the case of leaves. Branches spread out at different angles with the axis, and thus give rise to marked characters in the contour of trees.

Owing to various causes, it is rare to find all the buds properly developed. Many lie dormant, and do

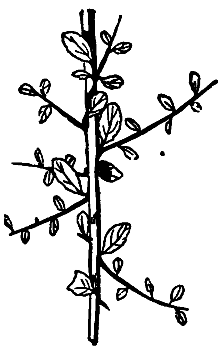


Fig. 66.

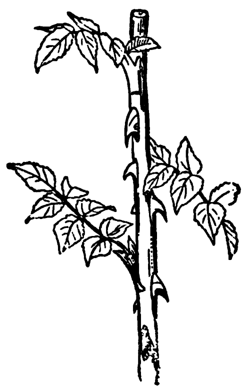


Fig. 67.

Fig. 66.—Branch of the sloe (*Prunus spinosa*), producing spines or thorns, which are abortive branches, as shown by their bearing leaves.

Fig. 67.—Rose branch, showing aculei or prickles, which are hardened hairs.

not make their appearance as branches unless some injury has been done to the plant; others are altered into thorns (figs. 1 and 66); others, after increasing to a certain extent, die and leave knots in the stem. That thorns are, in reality, undeveloped branches, is shown by the fact that they are connected with the centre of the stem, that they bear leaves in certain circumstances (fig. 66), and that under cultivation they often become true branches. Many plants are thorny in their wild state, which are not so under cultivation, owing to this transformation. Thorns, as seen in the hawthorn, differ totally from prickles, as seen in the rose. The latter are merely connected with the surface of the plant, and are considered as an altered condition of the hairs, which become hardened in their structure (fig. 67).

QUESTIONS.

1. What are buds, and what positions do they occupy on the stem?
2. How do Exogens and Endogens differ as regards the production of buds?
3. How are buds protected?
4. What connection have buds with the stem?
5. When palm-stems or fern-stems divide, what is the usual mode of division?
6. What are thorns? How do they differ from prickles?
7. What are knots in trees, and how are they produced?

Functions and Uses of the Stem.—The use of the stem is to support the leaves and flowers, and to expose them to air and light. The general form of stems is fitted to secure stability, and it is said that the bole of an oak suggested to Mr. Smeaton

the form best suited for the construction of the Eddystone Lighthouse. The sap circulates in the vessels and cells of the stem as well as in the canals between them. In its upward course, it passes chiefly through the internal parts, being moved onwards by

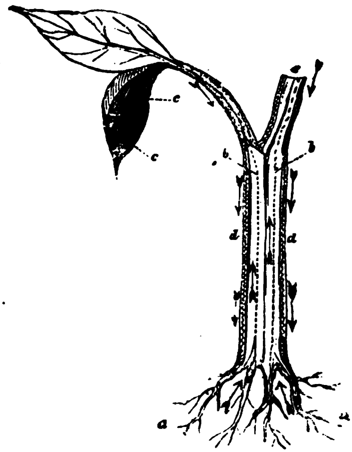


Fig. 68.

the force of imbibition, by capillary attraction, and by the action of the leaves. When it has reached the leaves and has undergone certain changes, it returns towards the bark in its downward course. The course in exogens is indicated in fig. 68. The sap enters by the cells of the roots *a a*, ascends through the central parts of the

Fig. 68.—Figure intended to represent the upward and downward course of the sap in exogens. *a a* the roots, *b b* vessels, cells, and intercellular canals of the stem, *c c* leaf-stalk and leaves, *d d* bark, *e* section of a branch. The direction of the arrows shows the course of the sap.

stem *b b*, reaches the leaves *c c*, and returns by the bark *d d*. The arrows are placed to point out this course. The fòrce with which the sap ascends is very great. It has also been observed that fluids pass from one cell or vessel to another, through the membrane which forms their walls, by what is called *osmose*. Constant movements of the fluids are thus going on in plants.

Various are the uses to which the woody stems of trees are applied. The heart-wood of exogens is more durable than the outer or sap-wood, and is less liable to attacks from dry-rot, which is caused by the growth of a peculiar kind of mould. The outer bark often becomes very thick, and in the cork-oak (fig. 54, p. 33) it supplies the important substance called cork. The inner bark is fibrous, and is used to furnish ropes and mats. Russian mats are procured from the inner bark (the *bast*) of the lime-tree (*Tilia Europæa*). Cuba bast is obtained from the bark of *Paritium tiliaceum*. The inner bark of the lace-bark tree exhibits meshes, like lace (fig. 69). Hemp and flax are the produce of the outer covering which corresponds to the bark. A kind of hemp in India is procured from the inner bark of a species of *Hibiscus*. Many of the nettle tribe also yield fibres from the bark. The Rhea plant of India (*Boehmeria nivea*) yields fibres used in manufactures. The common hollyhock, and other plants of the mallow tribe, also supply fibres. The inner bark of trees is used in some countries for

Fig. 69.

Fig. 69.—Fibres of lace-bark tree (*Lagetta lintearia*), anastomosing, with cellular tissue between them.

manuscripts, and hence the name of *liber* (a book) applied to it.

QUESTIONS.

1. What is the use of the stem, and what functions does it perform?
2. Describe the circulation of the sap in an ordinary exogenous tree.
3. What forces operate in causing the movement of the sap?
4. What is meant by osmose?
5. Mention some of the useful products furnished by the stems of trees.

IV.—On the Structure, Arrangement, Conformation, and Functions of Leaves.

Structure of Leaves.—Leaves exhibit an arrangement of cells and vessels, as seen in fig. 70, where the

Fig. 70.

dark lines indicate the vessels or veins of the leaf, and

Fig. 70.—Reticulated leaf of the white dead nettle (*Lamium album*), showing the distribution of the veins, or what is called venation. The edges of the leaf are serrate—*i.e.* cut like the teeth of a saw.

the intermediate spaces the cellular parts of it. On making a section of a leaf from the upper to the under surface, and examining it under the microscope, we see the texture more clearly. This is delineated in fig. 71. The skin or integument of leaves consists usually of two layers—a thin one on the outside (cuticle), and another immediately below it (epidermis). These two layers are not always easily distinguishable. In leaves growing under water, the cuticle alone can be detected.

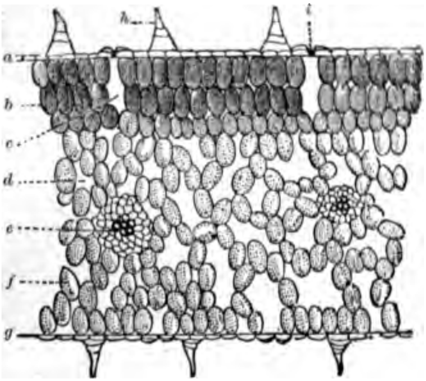


Fig. 71.

The integument or skin, on the upper side of the leaf, is marked *a* in fig. 71, that on the lower side of the leaf is marked *g*. Between these are cells, *b f*, and vessels, *e*. The cells at the upper side, *b*, are placed close together, with occasional air-cavities, *c*; those of the lower side,

Fig. 71.—Section of the leaf of a melon, perpendicularly to its surface; *a* upper integument or upper skin; *g* lower integument or lower skin; *b* cells of upper part of leaf; *f* cells of lower part of leaf; *e* bundles of vessels; *d* air cavities; *c* cavity below a stoma; *i* a stoma; *h* a hair.

f, are more loose, and have numerous air-spaces, *d*. The bundles of vessels forming the veins are marked *e*, while *h* indicates hairs projecting from the surface, and *i* an opening (stoma) through the skin into the cavity below. When leaves are left for a long time to macerate in water, the cellular part is destroyed, and

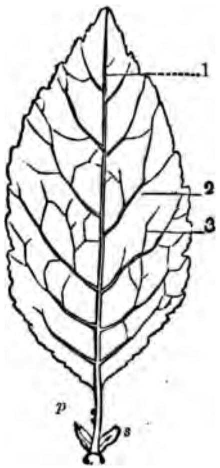


Fig. 72.

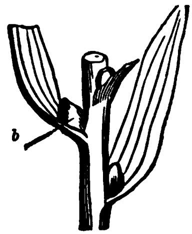


Fig. 74.

Fig. 73.

the veins or vascular parts are left, forming the skeleton. Leaves which have lain in ditches during the winter often exhibit a beautiful network of veins. In India

Fig. 72.—Leaf of cherry, showing distribution of veins in the lamina or blade. 1 midrib ; 2 primary veins, given off from the midrib ; 3 secondary veins ; *p* petiole or leaf-stalk ; *s* stipules.

Fig. 73.—Palm-leaf, showing parallel venation, the veins not being reticulated.

Fig. 74.—Stem of bulbiferous Lily (*Lilium bulbiferum*), showing bulbils or bulblets *b*, produced in the axils of the leaves, which exhibit parallel venation.

and China, skeleton leaves are made from the leaf of a kind of fig, called the Peepul tree (*Ficus religiosa*). Skeleton leaves may be prepared by maceration in rain-water for six or eight weeks, or more, in a warm place, freely exposed to the air. When nearly ready, carefully add a small quantity of muriatic acid, and finally pick out with care, by means of a needle, the cellular parts not rotted away. The whole may be bleached with chloride of lime, or simple chlorine, or the fumes of sulphur. By boiling leaves for a few minutes in a solution of caustic potash, the process is much expedited.

Venation.—As regards the distribution of veins in leaves (venation), flowering plants may be divided into

Fig. 75.

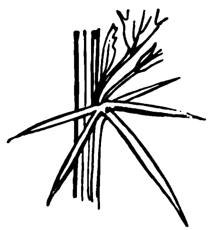


Fig. 76.

two classes: those having reticulated leaves, or exhibiting an angular network of vessels, as in fig. 72, which represents the leaves of the ordinary trees of this

Fig. 75.—Spiny leaf of Holly (*Ilex Aquifolium*). The spines are formed by the hardened extremities of the veins proceeding from the midrib to the margin.

Fig. 76.—Spiny leaf of the Barberry.

country; and those having no proper network, but a set of parallel or diverging veins running from the base to the extremity, as in grasses, lilies (fig. 74), and palms (fig. 73), or from the midrib to the margin, as in Bananas (fig. 13, p. 7), and Indian-shot. The first kind of leaf occurs in exogenous plants, the second in endogenous plants. This constitutes another means of discrimination between these two great classes of plants, and is one which can be easily detected by the student. In the case of some acrogens, as ferns, the veins are forked. In cellular plants, as seaweeds, there is no vascular venation, but veins are sometimes formed by condensed cells.

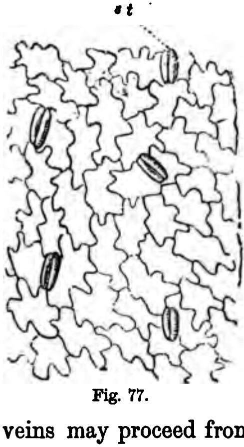


Fig. 77.

The primary veins may proceed from the midrib to the margin (fig. 72), or they may radiate from a point

Fig. 77.—Stomata *st*, or openings in the epidermis or skin of the leaf of Balsam. There are five of these represented in the figure, placed at regular intervals. They are concerned in the exhalation and absorption of fluids.

(fig. 99, p. 62). In the former case, the veins either go completely to the margin, or end within it in a curved manner.

Sometimes the veins of leaves become hardened at their extremities, and project in the form of thorns, as seen in the holly (fig. 75), and the barberry (fig. 76). The same remark may be made in regard to them as has been applied to other thorns. They are produced by an arrestment in the development of the cellular part of the leaf, and a change in the structure of the veins. In the case of the holly, we see that in certain circumstances it produces spineless leaves, in consequence of the cellular tissue filling up the spaces between the veins, even to the very edge.

Stomata and Hairs.—The surface of leaves presents certain pores or openings called stomata (fig. 77, *st;* and fig. 71, *i*, p. 49). The cells surrounding these pores are so constructed that in dry weather they collapse, and close the opening; while in moist weather they have a crescentic margin, by which they open the orifice. They are connected with the passage of air and fluids to and from the leaf. In fig. 77 they are seen scattered over the surface at regular intervals. They are easily observed in a very thin piece of the skin of the leaf of a hyacinth or lily placed under the microscope. They vary much in form and appearance in different plants. On the surface of leaves hairs are often produced (fig. 71, *h*, p. 49). They are formed from the cells of the skin or epidermis, and they are composed either of single cells (fig. 78), or of several cells united (figs 79 and 80). Sometimes hairs become

forked (fig. 81), or variously divided at the apex (fig.

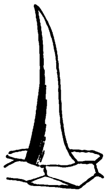


Fig. 78.

Fig. 79.

Fig. 80.

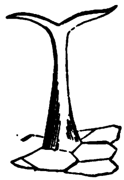


Fig. 81.

82 *a*); while at other times they assume a star-like form (fig. 82 *b*), or they unite to form scales (fig. 83).

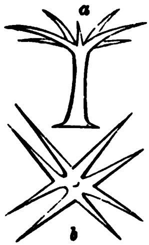


Fig. 82.

Fig. 83.

At the upper or lower extremities of hairs we meet in

Fig. 78.—Hair of common Cabbage. It is composed of a single elongated conical cell.

Fig. 79.—Hair of Marvel of Peru (*Mirabilis Jalapa*). It is necklace-like (moniliform), being composed of separate cells with contractions.

Fig. 80.—Sting of Nettle. Its base is formed of numerous cells containing an irritating fluid. It is called a glandular hair.

Fig. 81.—Forked or bifurcated unicellular hair of Draba or Whitlow-grass, one of the Cruciferous plants.

Fig. 82.—*a*, Hair of Alyssum, dividing at the top into rays in a forking manner; *b*, star-like hairs.

Fig. 83.—Radiating hair or scale of the Oleaster (Elæagnus). Such scaly hairs frequently give out waxy and other secretions.

some instances with cells containing peculiar secretions, as in the case of the Chinese primrose, the sundew (fig. 121, p. 74), and the nettle. The glandular hairs of the nettle are called stings (fig. 80).

Leaf-arrangement.—The mode in which leaves are arranged on the stem deserves notice. They are either placed opposite to each other, as seen in fig. 84, or alternate with each other, as in figs. 85 and 86. When leaves are opposite, we frequently find that the different pairs cross each other at right angles. Thus in fig. 84

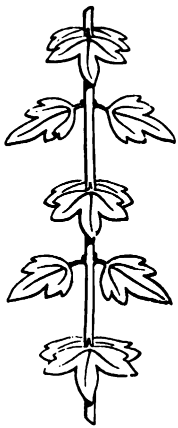


Fig. 84.

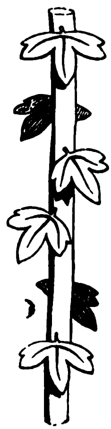


Fig. 85.

the two leaves at the base are placed to the front and back, the next two right and left, and so on. When

Fig. 84.—Opposite leaves on a stem; each pair is placed at right angles to that next it, thus following a law of alternation. In this case they are said to be decussate.

Fig. 85.—Alternate leaves. The sixth is placed directly above the first, and the fraction expressing the arrangement is $\frac{2}{5}$—viz. two turns round the stem and five leaves.

several occur at the same level, they become whorled (verticillate, fig. 86), and then the leaves of the separate whorls alternate with each other. There is thus seen a law of alternation. The alternate position of leaves seems to be connected with the formation of the woody matter of the stem, and with their free exposure to air and light. The law of alternation is distinctly visible in the case of single leaves produced at each point of the stem. In fig. 85 there are six leaves arranged at different heights on the stem, and it will be seen that the sixth leaf is directly above the first, and the same arrangement is seen in fig. 87, where the leaves are numbered

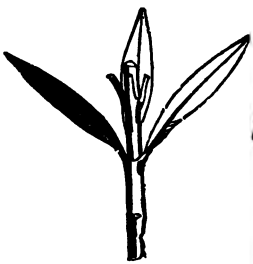


Fig. 86.

Fig. 87.

in succession 1, 2, 3, 4, 5, 6. Commencing with the lowest leaf in these figures, and proceeding regularly

Fig. 86.—Acute leaves of Rose-bay (*Nerium Oleander*) arranged in a verticil or whorl of three in the young state.

Fig. 87.—Alternate leaves, arranged in the same way as in fig. 85, the fraction expressing the arrangement being $\frac{2}{5}$. The sixth leaf is directly above the first, and there are five leaves in the cycle.

through all the leaves until we reach the one directly above the first, we follow a spiral direction, make two complete turns round the stem, and meet with five leaves. This arrangement is expressed by the fraction $\frac{2}{5}$. This means that there are five vertical rows of leaves, and that in passing from any one leaf to that directly above it, we make two turns round the stem, and meet with five leaves. In figs. 88 and 89 it is shown that in the case

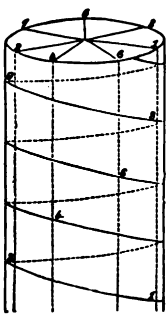


Fig. 88.

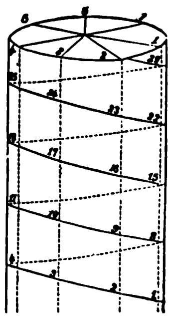


Fig. 89.

of alternate leaves perpendicular lines may be drawn through the leaves placed directly over each other, and the number of these lines indicates the number of leaves in each spiral cycle, or the number of leaves between any leaf on the stem and that directly above it. In both these figures it will be seen that the number of these lines is seven, and this, therefore, is the number of leaves in each cycle. But it will also be noticed

Figs. 88 and 89.—Diagrams to illustrate the arrangement of the leaves on the stem. In each figure the cycle consists of seven leaves. In 88 the divergence between every two leaves is $\frac{3}{7}$ of a circle, or $\frac{3}{7}$ of $360° = 154\frac{2}{7}$. In 89 the divergence between every two leaves is $\frac{1}{7}$ of $360° = 51\frac{3}{7}$.

that the number of turns made round the stem in completing the cycle is different. Thus in fig. 88, commencing with leaf No. 1 we reach leaf No. 8, or that directly above 1, after making three turns round the stem and the fraction indicating this is $\frac{3}{7}$; whereas in fig. 89 we reach No. 8 after one turn, and the fraction therefore is $\frac{1}{7}$. These fractions mark the angular divergence between any two leaves of the cycle, as represented in the divided circles at the upper part of the stems. In fig. 88, between 1 and 2 the angular divergence is obviously $\frac{3}{7}$, while in fig. 89 it is $\frac{1}{7}$ of the circle.

There is thus a spiral coil, consisting of a certain number of leaves—the cycle being determined by the leaf directly above that from which we start. The number of leaves in a cycle often varies according to the series, 1, 2, 3, 5, 8, 13, 21, 34, 55, etc., where it will be seen that each successive number is made up of the two preceding. It is also observed that in passing through the leaves forming the cycle, the number of turns which the spiral takes varies according to the same series of numbers. The fraction expressing their arrangement necessarily indicates the angle of divergence between any two leaves of the cycle—the divergence or horizontal separation of two leaves being measured by the arc of a circle (fig. 90, *b*) corresponding to an angle of which the summit is in the centre of the branch (fig. 90, *a*). Thus we arrive at a series of fractions, $\frac{1}{2}$, $\frac{1}{3}$, $\frac{2}{5}$, $\frac{3}{8}$, $\frac{5}{13}$, $\frac{8}{21}$, $\frac{13}{34}$, $\frac{21}{55}$, and so on.

In what is called the one-half arrangement the leaves are in two rows, and the third leaf is the one directly

above the first. In the one-third or two-thirds arrangement there are three rows, and the fourth leaf is directly above the first. In the two-fifths series there are five vertical rows of leaves, and the sixth is directly above

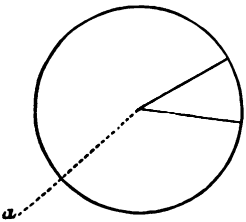


Fig. 90.

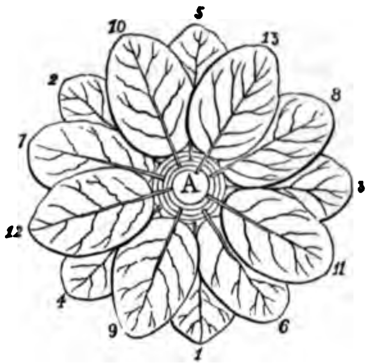


Fig. 91.

the first. The following figures will show the five-rowed arrangement:—

21	22	23	24	25
16	17	18	19	20
11	12	13	14	15
6	7	9	9	10
1	2	3	4	5

We thus perceive that a series of vertical lines may be drawn, passing through leaves which are placed directly

Fig. 90.—*a* Indicates the angle of divergence between two leaves, and *b* the arc of the circle which measures it.

Fig. 91.—Diagram of leaves of the House-leek (*Sempervivum tectorum*), showing a cycle of thirteen leaves, indicated by the fraction $\frac{5}{13}$. The observer is supposed to be looking downwards on the top of the rosette. There is a short axis A bearing the leaves. On this axis there have been described five revolutions of the spire, and the origin of each of the thirteen leaves is indicated.

over each other (figs. 88 and 89). If we can count five vertical rows, then we refer the arrangement to $\frac{2}{5}$; if 8, to $\frac{3}{8}$; and if 13, to $\frac{5}{13}$; and so on. When leaves are very crowded, the vertical ranks are not so evident as two or more rows of oblique or secondary spirals, which are seen winding in opposite directions. Still there is the same spiral arrangement of the leaves, as shown in fig. 91, where the crowded leaves of the house-leek are numbered according to their position. Similar spiral arrangements are seen in the scales of the fir-cone, which are looked upon as modified leaves.

Vernation.—The arrangement of the leaves in the


Fig. 92.

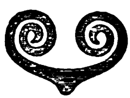


Fig. 93.

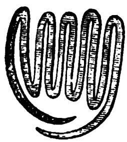


Fig. 94.

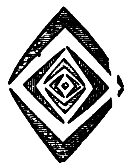


Fig. 95.

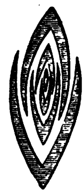


Fig. 96.

leaf bud is called *vernation*, and it furnishes important characters. Individual leaves in a bud may be folded from their midrib, as in fig. 92 (see oak-leaf), or rolled outwards (common dock), or inwards at their margins (fig. 93, see water-lily), or from top to bottom, as in

Fig. 92.—Two sides of the leaf folded on each other (conduplicate).

Fig. 93.—Edges of the leaf rolled inwards (involute); when rolled in the same way outwards they are revolute.

Fig. 94.—Leaf folded like a fan (plaited, plicate).

Fig. 95.—Leaves in a leaf-bud folded, and their edges applied to each other in a decussate manner (accumbent).

Fig. 96.—Leaves in a leaf-bud folded, and overlapping each other (equitant).

ferns, or they may be folded like a fan, as in the Lady's mantle and in the vine (fig. 94). The leaves in the bud, taken collectively, may be applied to each other at their edges, or they may overlap in various ways (figs. 95 Lilac, and 96 Iris).

QUESTIONS.

1. Describe the structure of an ordinary leaf from the upper to the under surface.
2. Describe the integument of leaves.
3. What is meant by venation ?
4. Divide leaves according to their venation.
5. How are spines in leaves formed ? Give an example.
6. Describe stomata.
7. What is the structure of hairs ?
8. What is meant by glandular hairs ? Give examples.
9. What is meant by star-like hairs ? How are they formed ?
10. What is meant by epidermal scales ? Explain their formation.
11. Mention a peculiarity in the hairs of the leaves of the nettle.
12. Describe the mode in which leaves are arranged upon the stem.
13. What is meant by opposite and alternate leaves ?
14. What is meant by whorled (verticillate) leaves ?
15. What is meant by decussate leaves ?
16. Mention the series of numbers exhibited in some of the leaf-arrangements.
17. Explain the meaning of the fractions $\frac{1}{2}$, $\frac{2}{5}$, and $\frac{3}{8}$, applied to the leaf-arrangement.
18. Explain the term vernation.
19. Describe some of the modes in which the leaves are folded in the bud, and give examples.

Conformation of Leaves.—The leaf consists of the

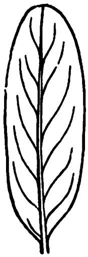


Fig. 97.

Fig. 99.

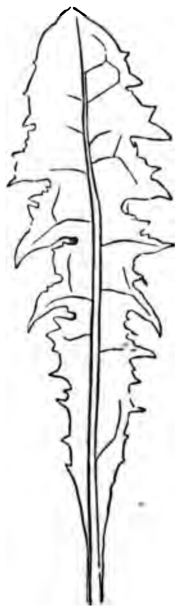


Fig. 98.

blade or lamina, and the leaf-stalk or petiole (fig. 72,

Fig. 97.—Simple oblong entire leaf of a species of Senna. The apex is obtuse or blunt, and the base is unequal.

Fig. 98.—Simple runcinate leaf of Dandelion (*Leontodon Taraxacum*). It is a pinnatifid leaf, with the divisions pointing towards the petiole.

Fig. 99.—Simple leaf of castor-oil plant (*Ricinus communis*). It is palmately cleft, and exhibits seven lobes at the margin. The petiole or leaf-stalk is inserted a little above the base, and hence the leaf is called peltate or shield-like.

p. 50). When there is no stalk, the leaf is called sessile (fig. 74, p. 50). The leaf-stalk is usually rounded; but sometimes it is flattened, or forms a sheath round the stem. At the base of the leaf there are occasionally leaflets attached laterally, and called stipules (figs. 72 and 100, *s*). The presence or absence of these leaflets

Fig. 100.

furnishes useful characters. Leaves are usually arranged under the heads of simple and compound; the former having a blade composed of one piece either perfectly entire or divided in various ways, and having no joint

Fig. 100.—Compound impari-pinnate (unequally pinnate) leaf of Robinia. There are nine pairs of shortly-stalked leaflets (*foliola, pinnæ*), and an odd one at the extremity. At the base of the leaf stipules *s* are seen.

beyond the points where the leaves are united to the stem (figs. 97, 98, 99); the latter having a blade divided into separate parts or leaflets, which are united by joints to the petiole or leaf-stalk (figs. 100, 109).

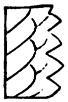


Fig. 101.

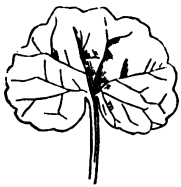


Fig. 102.

Fig. 103.

Fig. 104.

The form of leaves depends upon the mode in which the ribs and veins are distributed and the margins are divided. When a leaf or leaflet has no divisions on

Fig. 101.—Margin of leaf, toothed (dentate).

Fig. 102.—Leaf of Ground-ivy (*Nepeta Glechoma*), having a kidney-like form, and hence called reniform. Its margin is crenate. The venation is radiating.

Fig. 103.—Pinnately-partite leaf of a kind of Poppy. The segments of the leaf are pinnately-cleft.

Fig. 104.—Lanceolate leaf of willow, narrow and tapering to each end.

its margin, it is called entire (fig. 97); when the margin presents small acute projections, the leaf is toothed (fig. 101); when these projections are arranged like the teeth of a saw, the leaf is serrate (fig. 70, p. 48); and when the projections are rounded, the term crenate is applied (fig. 102).

Fig. 105.

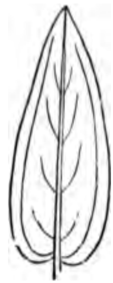


Fig. 106.

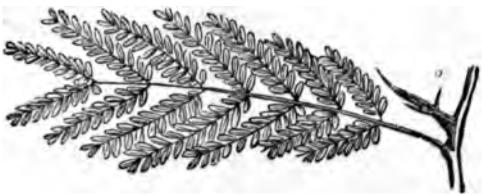


Fig. 107.

When a simple leaf is divided deeply in a lateral direction—*i.e.* from the margin towards the midrib—it is said to be pinnately-cleft or pinnatifid (fig. 98); if

Fig. 105.—Arrow-shaped leaf (sagittate) of Scammony.

Fig. 106.—Entire egg-shaped (ovate) acute leaf of Coriaria. It is also three-ribbed (tricostate).

Fig. 107.—Doubly pinnate (bipinnate) leaf of the Honey-Locust tree (*Gleditschia*); *b*, a spiny bud arising from the stem.

the divisions extend nearly to the midrib, then the term partite is used in place of cleft, and the leaf is pinnately-partite (fig. 103).

When a simple leaf is divided deeply in a longitudinal direction—that is, from the apex to the base—the terms palmately-cleft and palmately-partite are

Fig. 108.

Fig. 109.

used, and the number of divisions is indicated by a numeral prefixed. Thus, in fig. 99, there is a palmately-cleft leaf, and the divisions and lobes being seven, the name 7-cleft is also applied.

Fig. 108.—Wood-sorrel (*Oxalis Acetosella*), with its compound ternate leaves, which are said to display a certain amount of irritability when exposed to bright sunshine. During the night each of the three leaflets, forming the compound leaf, fold on their midrib, and then fall down towards the common petiole.

Fig. 109.—Compound septenate leaf of the horse-chestnut (*Æsculus Hippocastanum*). Such leaves are sometimes called digitate.

Various names are given to the forms of simple leaves, such as lanceolate, meaning narrow and tapering to each end (fig. 104); oblong, meaning narrow, but not tapering to each end (fig. 97); cordate, like the heart on cards; sagittate, like an arrow (fig. 105); ovate, or egg-shaped (fig. 106). When a heart-shaped leaf has the

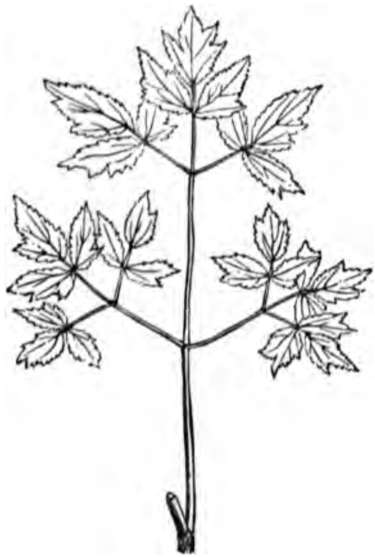


Fig. 110.

division of the heart at the point farthest from the stalk, it is obcordate; and when an ovate leaf has the broad part of the egg similarly placed, it is obovate.

In a compound leaf the divisions vary in a similar manner—taking place either laterally or longitudinally.

Fig. 110.—Triternate leaf of Baneberry (*Actæa*).

In this case, however, the divisions consist of separate leaflets usually articulated to the petiole or midrib. A compound leaf having leaflets placed laterally along the midrib is called pinnate (fig. 100, p. 63, and fig. 116). The leaflets are in pairs, and the leaf may end in a

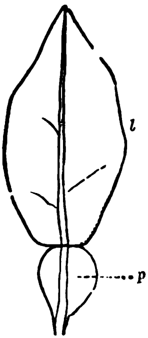


Fig. 111.

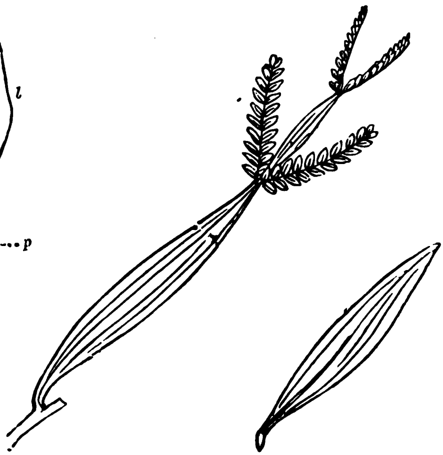


Fig. 113. Fig. 112.

pair of leaflets, or in one leaflet as in the figures. In the former case it is equally, in the latter unequally, pinnate. The leaflets themselves may be divided into a series of smaller leaflets in pairs, and then the leaf is twice pinnate (bipinnate, fig. 107). Further divi-

Fig. 111.—Leaf of orange (*Citrus Aurantium*), showing a winged petiole, *p*, which is articulated to the blade (lamina) *l*. It is a compound leaf with only one leaflet.

Fig 112.—Broadened leafstalk (*phyllodium*) of an Acacia, without any true leaves.

Fig. 113.—Leafstalk of the same Acacia bearing leaflets.

sion on a similar plan will make it thrice pinnate (tri-pinnate), and so on.

A compound leaf formed of leaflets jointed to the top of the leafstalk (the divisions being thus longitudinal) is named according to the number of the leaflets—ternate, when they are three (fig. 108); quinate, when they are five (*Pavia*); septenate, when seven (fig. 109); and digitate when they are numerous (*Lupinus*

Fig. 114.

Fig. 115.

polyphyllus). When a ternate leaf divides twice into three, it becomes biternate (Columbine); when thrice, triternate (fig. 110).

Petiole or Leaf-stalk.—The petiole or leaf-stalk is

Fig. 114.—Plant of water-chestnut (*Trapa natans*). The submerged leaves are much divided; those which float have inflated petioles, containing numerous air-cells. The swelling below the blade of the leaf indicates the situation of the air-cavities.

Fig. 115.—Leaf of Pansy, *l*, separated from the flower; the pinnatifid stipules, *s*, are distinctly visible, and their lateral position is seen,

usually rounded in its contour, and it is either articu-

Fig. 116.

lated to the stem or branch, as in the case of ordinary deciduous trees, or it is continuous with the stem,

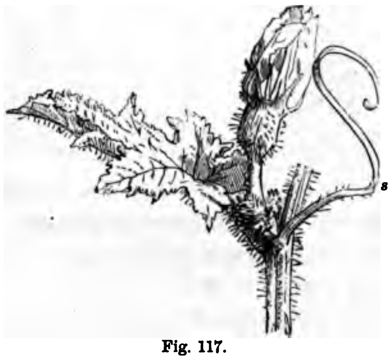


Fig. 117.

as in lilies and hyacinths, and then withers without fall-

Fig. 116.—Compound pinnate leaf of rose, with two stipules at its base united to the leaf-stalk and to each other.

Fig. 117.—Wavy leaf of melon, with a stipule, *s*, in the form of a tendril.

ing off at an articulation. The petiole is flattened from side to side in the aspen, and it is broadened out into a leaf-like body in the orange (fig. 111), and in some acacias (fig. 113). In many acacias of Australia the petiole serves the purpose of leaves, and no true leaves are produced (fig. 112). In some aquatics the leaf-stalk is full of air, so as to enable the leaves to float on the surface of the water, or to rise above it (fig. 114).

Stipules.—These are small leaf-like bodies situated at the base of the leaf stalks, and having in their normal state a lateral position as regards the leaves. In some plants they occupy the place of the true leaves. They are well seen in the common pansy (fig. 115). In the rose the two stipules are united together so as to form a broad expansion at the base of the petiole (fig. 116). In rhubarb the stipules form a sheath round the stalk, and in the cucumber tribe they are in the form of tendrils (fig. 117). In the case of Peruvian Bark trees and the Ipecacuan plant, the stipules are placed between the opposite leaves on each side of the branch.

QUESTIONS.

1. What is meant by the conformation of leaves?
2. What is the meaning of the terms lamina and petiole?
3. What are stipules?
4. How have leaves been arranged in regard to their general conformation?
5. Explain the meaning of a simple and of a compound leaf, and give an example of each.
6. Explain the terms entire, toothed, serrate, and crenate, as applied to leaves.
7. Explain the terms pinnatifid and pinnati-partite.
8. Explain the terms palmately-cleft and palmately-partite.

9. Explain the terms lanceolate, oblong, cordate, and ovate.
10. Explain the terms obcordate and obovate.
11. Explain the term sagittate.
12. Explain the terms pinnate, bipinnate, and tripinnate.
13. Explain the terms ternate, biternate, and triternate.
14. Explain the terms quinate, septenate, and digitate.
15. What is meant by a sessile leaf?
16. Describe the petiole of the orange.
17. Describe a peculiarity in the leaf-stalk of some Australian acacias.
18. Describe the position of stipules.
19. What kind of stipules are seen in the pansy and in the rose?
20. Are stipules present in all plants?

Anomalous Leaves.—Leaves exhibit peculiar shapes

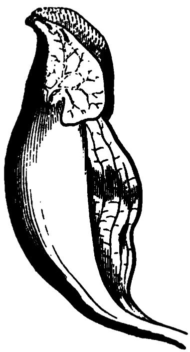


Fig. 118.

Fig. 119.

in consequence of being folded so as to form bags

Fig. 118.—Pitcher of *Sarracenia purpurea*, a North American marsh plant.

Fig. 119.—Pitcher of *Nepenthes distillatoria* from the Indian Archipelago. It hangs by a narrow portion from the end of the leaf, and has a distinct lid which closes the orifice at first.

or pitchers. There are various kinds of pitcher-plants. The pitcher of an American pitcher-plant (*Sarracenia*) is represented in fig. 118, while that of an East Indian plant (*Nepenthes*) is seen in fig. 119. In the latter there is a distinct lid, which is folded over the mouth of the pitcher at first, but ultimately rises, as shown in the woodcut. The fluid in the pitcher before the lid opens contains certain saline matters in solution. One of the Indian pitcher-plants, called *Dischidia Rafflesiana*, climbs to the top of the lofty trees and produces pitchers only among the upper leaves. There it is that the plant sends out little rootlets, which enter the pitchers and derive nourishment from the rain and dew which are thus collected.

These pitchers often contain numerous insects, which are attracted in some cases (as in Sarracenias) by a viscid honey-like substance secreted on the inner surface of the pitcher, and extending a short way from the margin.

Irritable Leaves.—An interesting phenomenon exhibited by the leaves of plants is irritability. This is manifested by certain movements which they display either spontaneously or under the influence of mechanical and chemical stimuli. In the plant called Venus's fly-trap (fig. 120) the leaf is furnished with three projecting hairs on its blade, as seen in the expanded leaf on the figure, which, when touched, immediately cause the leaf to fold upon itself, and thus enclose any insect that may have alighted on it. This plant has been called insectivorous and carnivorous, because insects and albuminous food, entrapped in its leaves, are acted on by an acid secretion (allied to for-

mic acid) and are gradually digested, so as to supply nourishment to the plant. A similar phenomenon is seen in the leaves of the Sundew (*Drosera,* fig. 121), which

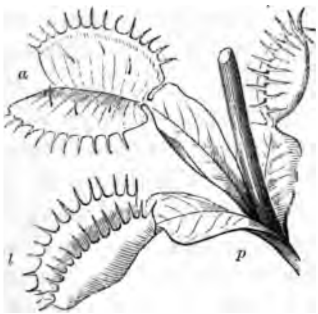


Fig. 120.

Fig. 121.

are covered by glandular hairs or tentacles which secrete a viscid fluid and gradually close upon any insect which alights on them, and finally digest it. Albuminous food placed on the leaf is acted on in the same way. Some species of Butterwort (*Pinguicula*) appear also to detain insects in the curled margin of their leaves. In the sensitive-plant (fig. 122), the slightest touch causes the little leaflets to fold to-

Fig. 120.—*Dionæa muscipula,* Venus's fly trap, a North American marsh-plant, which displays irritability of its leaves. One leaf, *a,* is expanded, showing the two parts of the blade with three projecting hairs on each, which, when touched, cause the parts of the blade to fold, as shown in the other two leaves. The petiole, *p,* is broad, and is said to be winged. A partially-closed blade of the leaf is marked *l.*

Fig. 121.—Leaf of a species of Sundew (*Drosera rotundifolia*) covered with glandular hairs or tentacles. These hairs secrete a viscid fluid, which often detains insects. The leaves are sometimes seen partially folded. This folding is supposed to be due to irritability.

gether in the way shown in the figure, and if the irritation is continued, the whole leaf falls down. These movements are also induced by the action of ether, chloroform, prussic acid, and many other substances. If the cause of irritation is removed, and the plant is left undisturbed, it gradually recovers

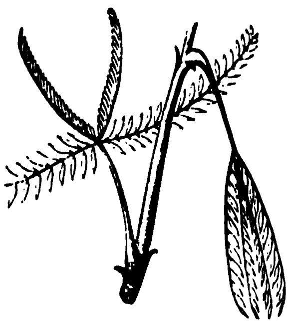


Fig. 122.

Fig. 123.

its natural state. During the night, the leaflets close and the leaf is depressed. In the moving-plant of India (*Desmodium gyrans*) as shown in fig. 123, there are two or more little leaflets, which are in constant motion, jerking from one side to the other in a remarkable manner, both during light and darkness. The large

Fig. 122.—*Mimosa pudica*, sensitive-plant. The stem with two leaves. Each leaf is composed of numerous leaflets on a common stalk. In the lower leaf, the leaflets are expanded at one part and closed at the other. In the other leaf all the leaflets are closed, and the whole leaf has fallen down.

Fig 123.—*Desmodium* or *Hedysarum gyrans*, the moving-plant of India. The large leaf moves slowly and imperceptibly from side to side, as well as upwards and downwards. The little leaflets are constantly jerking so as to meet in the middle and then separate again.

leaf at the end of the stalk also exhibits slow movements, rising and falling and moving from one side to the other. During darkness, the large leaf always hangs down. These remarkable movements exhibited by the leaves of plants are not connected with nerves or muscles, as is the case in animals, but they seem to be caused by the greater or less distension of cellular enlargements connected with the bases of the leaflets and of the leaf-stalks.

QUESTIONS.

1. How are vegetable pitchers formed? Mention two kinds, and describe the difference between them.
2. What is meant by irritable leaves? Give an example.
3. Describe the movements in the leaf of Venus's fly-trap.
4. Describe the movements in the leaf of the Sundew (*Drosera*).
5. Mention some plants which are called insectivorous and carnivorous, and explain the meaning of these terms.
6. Describe the movement in the leaf of the sensitive-plant.
7. Describe the movements in the leaves of the moving-plant of India.

Functions of Leaves.—In the form and size of leaves we may perceive many interesting adaptations. Thus the large fan-shaped leaves of palms are fitted for shade and shelter in the warm countries in which they grow; while the narrow linear leaves of pines and firs fit them for the alpine districts in which storms and blasts prevail. In leaf-buds also, wonderful provision is made by the Creator for the preservation of their contents. They are a sort of winter-quarters, in which the young leaves and branches are nursed. With this view they are covered with coarse external leaves, or with a coat-

ing of gummy or resinous matter. It is only when the genial warmth of spring calls them forth that they burst their cerements, and expand their delicate structures to the air. Our native plants protrude their leaves cautiously, and thus are seldom injured much from our variable springs; but exotics transplanted from temperate climes, where spring is continuous, and there are no nipping frosts to arrest growth, are often, as it were, deceived by a few days of warmth in our northern climate, put off their winter clothing too soon, and thus suffer severely from their temerity. The time of putting forth the leaves, as well as the time of the falling of the leaves, indicates the nature of the seasons.

The function of leaves is to expose the juices of the plants to light and air, and thus to aid in forming the woody matter of the stem, and the various secretions. Unless the leaves are freely exposed to air and light, the wood is not properly formed. Hence the reason why the wood is deficient both as regards quantity and quality in trees grown in crowded plantations. The same observations apply to all secretions of plants. Thus potatoes grown in the shade, by which the functions of their leaves are impeded, become watery, and produce little starch in their tubers. Leaves also give off a quantity of watery fluid. This constitutes what is called exhalation. The amount of fluid exhaled varies according to the structure of the leaves and the nature of the climate. When the texture of the leaf is hard and dry, as in some Australian plants, or the skin covering the leaf is thick and dense, and has few stomata, as in the American aloe and in the oleander,

the exhalation is comparatively small. In this way certain succulent plants, as cactuses, are enabled to withstand the effects of dry and hot climates without being dried up by the great loss of fluid from exhalation. The thick covering of hairs, as well as the waxy coating on some leaves, seem to be connected with the amount of exhalation. Some very hairy plants have been known to withstand the effect of great and continued drought. "Plants exhale fluid from their leaves, in the first place, for their own benefit. But various important secondary effects follow from this process. One of these is maintaining a suitable portion of humidity in the air. Not only do they attract and condense the moisture suspended in the air, and borne by the wind over the earth's surface, which, falling from their leaves, keeps the ground below moist and cool; but they can, by means of their roots, pump it up from a very considerable depth, and, raising it into the atmosphere, diffuse it over the face of the country. Trees, by the transpiration from their leaves, surround themselves with an atmosphere constantly cold and moist. They also shelter the soil from the direct action of the sun, and thus prevent evaporation of the water furnished by rains." In this way they contribute, as Humboldt states, to the copiousness of streams. When forests are destroyed, as they have been in America by the European settlers, with an imprudent precipitation, the springs are entirely dried up, or become less abundant. The inconsiderate felling of woods, or the neglect to maintain them, has changed regions noted for fertility into scenes of sterility.

The droughts which so often visit the Cape de Verd Islands are attributed to the removal of their forests. A disregard of this point may do great harm to Australia—a country where drought is already sufficiently injurious. In wooded countries, where the rains are excessive, as in Rio Janeiro, the climate has been improved by the diminution of the trees.

Another and most important function of leaves is to keep up the purity of the atmosphere. A poisonous gas, called carbonic acid gas, is constantly sent into the air by the breathing of man and animals, and by the various processes of combustion; and this gas is decomposed by leaves and the green parts of plants, under the influence of light. They are thus enabled to separate the carbon for their own use as food, and to give out oxygen gas, which constitutes the part of the air necessary for breathing. The carbonic acid gas exhaled from the lungs of a single individual in twenty-four hours contains, on an average, five to eight ounces of carbon—a substance familiar to all in the form of wood-charcoal. A full-grown man, therefore, will give off from his lungs, in the course of a year, 110 to 180 pounds of carbon in the form of carbonic acid. "If we suppose," says Professor Johnston, "each individual of Great Britain, young and old, to expire only 80 pounds of carbon in a year, the 20 millions would emit 700,000 tons; and allowing the cattle, sheep, and all other animals to give off twice as much more, the whole weight of carbon returned to the air by respiration in this island, would be about 2 millions of tons." Besides this, we must take into calculation the quantity

derived from the combustion of about 20 million tons of coal in order to ascertain the amount to which the atmosphere in Britain is vitiated. All the carbon is employed in the growth of plants. The exhalation from the leaves of plants grown in ordinary rooms is

Fig. 124.

so great that the plants will not thrive. To obviate this, and to prevent the effects of the noxious gases (such as sulphurous acid and sulphuretted hydrogen)

Fig. 124.—Wardian Case for a drawing-room, consisting of a strong wooden box or trough, *a*, supported on a stand, and covered with a glazed frame, *b*. The box is filled with loam, sand, and peat, laid over a layer of gravel and broken bricks. Water is freely poured over the soil at first, and it is allowed to drain off by means of two holes in the bottom of the box, which are subsequently stopped up with corks. After the plants have been put into the soil, the glazed frame, made of wood, zinc, or brass, is fitted on carefully in a groove on the upper part of the box. In the frame there is a glass door for the purpose of allowing the removal of dead leaves, and of permitting air to enter freely when the atmosphere in the case is too moist.

and the smoke of towns from injuring the plants, Mr. Ward invented glass Cases, which bear his name, in which cultivation is carried on successfully (fig. 124). In these Cases the water exhaled from the leaves is condensed on the glass and falls down again. Ferns succeed remarkably well in such Cases.

The leaves of plants growing vigorously are thus made subservient by the all-wise Creator to most important ends. The carbon, which in its combination with oxygen is so deleterious, is an important ingredient in plants, and is taken up by them in the form of carbonic acid. Plants of warm climates, with large evergreen leaves, and under the blaze of a tropical sun, contribute to supply pure air to other regions where the leaves fade and the light is deficient. It is only during light that leaves have this decomposing power. During the night no such process goes on; and if the leaves are kept long in darkness they lose their green colour, become pale and sickly, and deteriorate the air.

In preparing certain delicacies for the table, the gardener blanches plants—that is to say, he makes them grow in darkness, or at least partially covered from the light. In this way the plants lose their green colour, and they do not form their proper secretions. In place of fibrous matter, only delicate cells and spirals are produced, and the plants are rendered tender. Thus the leaf-stalks of celery and sea-kale, and the shoots of asparagus, are made fit for use. The heart of the cabbage is rendered white and delicate by the outer leaves screening it from light. By the same process the odours of plants are weakened or destroyed.

In ponds and lakes we perceive the balance kept up between animal and plant life. Plants, under the influence of light, decompose the carbonic acid given off by animals, and produce oxygen gas, which aerates the water. The heat and light received by plants for their growth do not disappear, but are treasured up in the tissues, and when the tree is burnt, it restores again the heat and light consumed during its growth.

The Fall of the Leaf (Defoliation).—The leaf, after performing its functions, dies, and either falls off at once, leaving a scar, or remains for a certain time attached to the plant. In the case of lilies and hyacinths the leaves decay gradually, and remain for a long time as withered unsightly appendages. Provision is made for the fall of the leaf. Long before this, a plane of separation begins to form at the base of the leaf-stalk, and it reaches its full development just at the time when the leaf ought to fall. A scar is left at the point of the stem where the leaf was attached. These scars give characters to plants both in a living and fossil state, and deserve careful study. Dr. Fleming divides trees, according to the duration of their leaves, into three classes :—1. Those in which the leaves cease to perform their functions when the bud is complete. 2. Those in which the leaves continue to perform their functions until new ones appear the following season. 3. Those in which the leaves continue to perform their functions for several years. The leaves of the first class are deciduous, and they seem to be connected with the ripening of the bud. When this takes place, these leaves change their colour

and perish. This may be seen in willows. Leaves of the second class are annual. They continue till new leaves are produced, and are cast off in the order of their development. In evergreen trees and shrubs the leaves of one season continue their functions until those of the next season are produced. The leaves of the third class are persistent. Their duration does not seem to be regulated by the perfection of the bud, nor by the development of new leaves. They continue their functions for several years. This is the case with ordinary evergreen firs. The leaves of the Chilian Pine (*Araucaria imbricata*) are remarkably persistent. In the case of pines, larches, cypresses, Thujas, Taxodium distichum, and other coniferous plants, as well as in Tamarisk, small branches fall off with the leaves—the decaying parts separating by a process of disarticulation or disjointing. This is called *cladoptosis* (branch-falling), as distinct from *phylloptosis* (leaf-falling).

How exquisite is the structure of a leaf, with its delicate cells and vessels, its coloured particles, beauteous even in decay, its pores, its hairs, which sometimes display a continuous circulation of fluids, as seen in the nettle, its sensitive movements, its air-cavities when required for floating, and its pitchers to carry fluids for nourishment! How wonderful to think that a feeble leaf fluttering in the breeze is not an isolated object in creation, but connected by the closest ties with the earth, the atmosphere, and the sun itself!

The parts of the plant which we have now con-

sidered—the root, stem, and leaves—constitute what are called the organs of nutrition or nourishment. Fluid matters are taken up by the cells of the roots from the soil, they are conveyed to the leaves, and there, under the influence of air and light, they are fitted for the purposes of plant-life, and for the production of various secretions, such as starch, gum, sugar, woody matter, gluten, oils, and resins. The nature of the soil has a material influence on the nourishment of the plant, and the process of manuring is conducted with the view of supplying certain substances which the plant requires for its vigorous growth, and which it cannot get from the particular soil in which it is placed. Some plants require ingredients which others do not need; and it is upon this principle that a certain rotation or change of crop is adopted.

QUESTIONS.

1. What are the functions of leaves?
2. How are leaves protected in the bud?
3. What changes take place in plants when grown in the dark? Give an example.
4. What is meant by the exhalation of leaves? What matters are exhaled?
5. What is meant by leaf-absorption? What matters are absorbed?
6. What effect do leaves produce on the atmosphere?
7. Whence arise the difficulties of growing plants in cities and in the rooms of houses?
8. Describe a Wardian Case, and explain its use.
9. What poisonous gas is absorbed largely by the leaves of plants?
10. What gases in the atmosphere of manufacturing towns are specially injurious to plants?

11. What is meant by defoliation and disarticulation ?
12. Mention modes in which leaves decay in autumn.
13. How can the nature of the seasons be indicated by the leaves of trees ?
14. What is meant by a leaf-scar ?
15. Do all leaves fall annually ?
16. What is meant by evergreen trees and shrubs ?
17. What is meant by persistent leaves ? Give an example.

V.—General Remarks on the Functions of the Organs of Nutrition.

Plants derive their nourishment partly from the atmosphere and partly from the soil. The parts (organs) of plants are made up of several chemical elements, which are combined in various ways, so as to form what are called *Organic* and *Inorganic* compounds. The former are composed of carbon, oxygen, hydrogen, and nitrogen (sometimes called azote), along with certain proportions of sulphur and phosphorus, while the latter consist chiefly of metals combined with oxygen, other metalloids, and acids. In all plants there is a greater or less proportion of water, the quantity of which is ascertained by drying at a temperature a little above that of boiling water. By burning the dried plant the organic constituents disappear, and the inorganic part is left in the form of ash.

As plants have no power of locomotion, it follows that their food must be universally distributed. The atmosphere and the soil accordingly contain all the materials requisite for their nutrition. These materials

must be supplied either in a gaseous or a liquid form, and hence the necessity for the various changes which are constantly going on in the soil, and which are aided by the efforts of man.

Carbon (C) is the most abundant ingredient in plants. It forms from 40 to 50 per cent of all the plants cultivated for food. It is familiar to us in the form of wood-charcoal, and is seen in its finest state in the diamond. It enters largely into the composition of coal which has been formed from plants of former epochs of the earth's history. Carbon is porous, and has the property of retaining within its pores a considerable amount of soluble gases, such as ammonia and sulphurous acid; it also absorbs various saline matters from solution, and it removes offensive odours. It exists largely in the *humus* or vegetable mould formed by the decay of plants. This mould, by its absorbing power, furnishes important materials for the nutrition of plants. Peaty soil contains a large amount of carbon. When carbon is burnt in the air, it combines with two atoms of oxygen, and forms a gas called carbonic acid, or carbon dioxide ($C\ O_2$). In this state carbon is taken up by the leaves and other green parts of plants, either in the form of gas, or in solution in water. This gas is produced during the burning of all organic substances; it is also given off during the process of fermentation. The breathing of man and animals is in reality a process of burning called oxidation, by which the oxygen of the air combines with the carbon in the lungs, and forms carbonic acid. The presence of this gas in the air given out from the lungs is shown

by breathing on, or by sending the breath by means of a glass tube through, a solution of lime water. A milkiness is at once produced in the fluid by the formation of the insoluble carbonate of lime (chalk). During the decay of animal and vegetable matter, $C O_2$ is produced, and it is present in large quantity in the atmosphere during volcanic action. The atmosphere contains only about one ten-thousandth of its bulk of carbonic acid, but this is sufficient to supply the carbon required for vegetation. Under the agency of light upon the green parts of plants carbonic acid is decomposed, its carbon being used for the nutrition of the plants, and its oxygen given off.

Oxygen (O) enters into the composition of plants. It exists in the atmosphere, in the proportion of about 21 per cent, along with nitrogen. It forms eight-ninths by weight of water. It is chiefly in its state of combination with hydrogen to form water ($H_2 O$) that it is taken up by plants, but also in combination with carbon, as carbonic acid. In combination with metals and metalloids, oxygen forms nearly three-fourths of the mass of the globe.

Hydrogen (H) is not found in a free state in nature. It forms one-ninth by weight of water, and is present in the atmosphere in combination with nitrogen. It is also found in the air, united with sulphur (S) and carbon, as a product of vegetable decay. By the decomposition of water, under the combined action of chlorophyll and sunlight, plants obtain their supply of Hydrogen.

Nitrogen (N) is another element found in plants. It forms about 79 per cent of the atmosphere, and abounds

in animal tissues. It is therefore necessary for the purposes of animal life that nitrogen should be supplied in food. Animal matters during their decay give off nitrogen, combined with hydrogen, in the form of ammonia ($N H_3$), which is largely absorbed by water as well as by carbon, and seems to be the chief source whence plants derive their nitrogen. It appears also that during thunderstorms the nitrogen and oxygen sometimes combine to produce nitric acid ($N_2 O_5$), which may furnish a supply of nitrogen.

These four elementary bodies are thus supplied to plants chiefly in the form of carbonic acid ($C O_2$), water ($H_2 O$), and ammonia ($N H_3$). The products formed from them are divided into two kinds—(1), those which contain no nitrogen and are called non-nitrogenous or unazotised; and (2), those which contain all the four, and are called nitrogenous or azotised. The first are chiefly concerned in furnishing materials for breathing (respiration), while the latter aid in the formation of blood and of muscle. Among the non-nitrogenous compounds formed by plants may be noticed cellulose, lignin, starch, gum, and sugar; while among the nitrogenous matters may be mentioned fibrin and albumin.

Cellulose is present in all plants forming the walls of cells and vessels. It may be called the basement tissue. Pure cellulose is white, tasteless, and is not soluble in water, alcohol, ether, or oils. In the hairs of cotton and in the pith of plants it is found nearly pure. By the action of sulphuric acid it is formed into grape-sugar. In its natural state it is not colourable

by iodine, but when acted upon by sulphuric acid, a blue colour is produced by the addition of iodine. By the action of sulphuric acid and nitric acid, cellulose is converted into gun-cotton (Pyroxylin).

Lignin is the substance which gives hardness and solidity to the cells and vessels of plants. It forms the encrusting matter in the interior of the woody tubes. It exists in linen and paper, and these substances, when acted upon by sulphuric acid, are converted into grape-sugar. Lignin exists in large quantity in the wood of trees. The ligneous layers of the bark are used for making ropes, and, after maceration, for paper. During decay, lignin is converted into humus or peaty matter.

Starch is a general product, being laid up as a store of nourishment, and undergoing changes at certain periods of the life of a plant, which fit it for further use in the economy of vegetation. It consists of organised granules, which are insoluble in cold water, alcohol, and ether. When heated with water to about 70° Cent., the granules swell up and split up, forming, on becoming cool, a gelatinous mass. When a small quantity of hydrochloric and nitric acid is added to starch, heated to about 105° Cent., it is converted into a substance called dextrin. Similar changes take place in the starch during the progress of vegetable growth. Starch is converted first into dextrin, and then into grape-sugar. A blue colour is produced in starch by the action of iodine.

Gum is one of the substances produced abundantly in the vegetable kingdom. Its composition is the same

as that of cane-sugar. It exists in many seeds, exudes from the stems and twigs of many trees, such as species of acacia, cherry, and plum, and is contained in the juices of others from which it does not exude. It is one of the forms through which organic matter passes during the growth of plants.

Sugar is another substance which exists in many species of plants. Like the substances just mentioned, it consists of carbon combined with oxygen and hydrogen in the proportion to form water. It is one of the carbo-hydrates. There are two marked divisions of sugar—viz., cane-sugar or sucrose, and grape-sugar or glucose. The former is procured from the sugar-cane, from beet-root, and the sugar-maple; it differs slightly in its composition from grape-sugar. The latter (grape-sugar) is a product of germination, being formed during the early growth of the embryo plant, and it exists in many kinds of fruit, such as grapes, gooseberries, apples, currants, and pears. It may be prepared from starch by the action of an infusion of malt.

The nitrogenous or azotised organic substances found in the tissue of plants are well seen in the glutinous part of wheat. The nutritive part of the wheat consists of starch or unazotised matter, separable by washing, and of azotised water or glutin. Azotised products are particularly abundant in grains and seeds. The glutin in them is composed of substances which receive the name of fibrin, casein, albumin, emulsin, all containing carbon, oxygen, nitrogen, and hydrogen, with some phosphorus and sulphur.

The inorganic substances which constitute the ash

left after burning are formed more or less by the following elements, sulphur (S), phosphorus (P), silicon (Si), chlorine (Cl), iodine (I), fluorine (F), potassium (K), sodium (Na), calcium (Ca), magnesium (Mg), iron (Fe), manganese (Mn), and perhaps aluminum (Al), and bromine (Br). The quantity of inorganic matter in plants is small compared with the organic constituents, nevertheless it is essential for the life and vigour of the plant.

In the interior of cells we meet with green corpuscles called chlorophyll, and a formative matter called protoplasm. The action of light is required for the development of chlorophyll, and by the aid of light it decomposes carbonic acid and sets free oxygen. It undergoes changes of colour during plant growth, and in autumn assumes various tints—red, yellow, brown, etc. Protoplasm is a nitrogenous matter concerned in the growth and development of cells. It is contained in the cells of plants, but it is said that some of the lowest plants and animals consist of this substance uncovered by any cell-wall.

QUESTIONS.

1. Whence do plants derive nourishment ?
2. What is meant by organic and inorganic compounds ? Give examples.
3. When plants are burnt, which of their compounds are destroyed, and which are left unconsumed ?
4. Whence do plants derive their carbon ?
5. What is the symbol of carbon ?
6. What is the composition of water ? Give its symbol.

7. Whence do plants derive oxygen and hydrogen ?

8. Whence do plants derive nitrogen ? Give the symbol of nitrogen, and of one of its compounds.

9. What gas is given off during the breathing of men and animals ?

10. Mention some nitrogenous and some non-nitrogenous substances found in plants.

11. What is meant by cellulose ?

12. What is lignin ?

13. What is meant by carbo-hydrates ? Give examples.

14. What is starch ? What plants yield it ?

15. What is gum ? What plants yield it ?

16. What is sugar ? Mention two kinds of sugar, and the plants which yield them.

17. What kind of sugar is produced during the germination or sprouting of plants ?

18. Mention some azotised organic substances produced by plants.

19. What effect has iodine on starch ?

20. What change takes place in starch during the growth of the young plant ?

21. Mention some of the inorganic constituents of plants.

22. What is protoplasm ?

23. What is chlorophyll ?

CHAPTER II.

THE ORGANS OF REPRODUCTION.

THE flower, or the floral organs concerned in the production of seed containing the young plant, are called the Organs of Reproduction. In exogens and endogens these organs are usually obvious, and hence these plants are called Flowering or Phanerogamous—*i.e.* with reproductive organs conspicuous. In acrogens, on the other hand, these organs are obscure, and hence the plants are called Flowerless or Cryptogamous—that is, having concealed organs of reproduction. We shall consider, in the first place, these organs as seen in flowering plants.

I.—BRACTS, FLOWER-STALKS, AND THE ARRANGEMENT OF THE FLOWERS ON THE AXIS.

The arrangement of the flowers on the flowering stem or branch is called Inflorescence. Flowers are produced from flower-buds, which arise like leaf-buds from the axil of leaves—that is, from the angle formed by leaves coming off from the axis. Leaves which give origin to flower-buds are called Bracts. They are sometimes similar to the ordinary leaves of the plant, at other times they are altered and modified in various ways. In fig. 125 is seen the common scarlet pimper-

nel, with each of the sessile (not stalked) leaves or bracts producing a flower; in this case the bracts are like the ordinary leaves of the plant. Such is also the case in the ivy-leaved speedwell, but in it the leaves are alternate in place of being opposite. In other cases, however, the bracts differ from the ordinary leaves. Sometimes they are beautifully coloured like the leaves of the flower, sometimes they are mere scales. While in some instances they give origin to one flower, in others they give rise to many flowers. In fig. 126 the common snow-flake is seen bearing a single flower with a bract *b*, which in the early state covers the flower; while in fig. 127 the polyanthus-narcissus is represented with a sheathing bract enclosing many flowers. In the common cuckoo-pint, and in palms, large bracts are seen enclosing numerous flowers. In the case of some palms the number of flowers covered by one sheathing bract or spathe is said to be upwards of 200,000. In grasses the bracts covering the flowers are called glumes. The simplest kind of inflorescence or floral arrangement is that in which single flowers are supported on flower-stalks arising from the axil of leaves, as in the gentian-ella, the snow-flake (fig. 126), the common periwinkle, and the pimpernel (fig. 125). In these instances, however, there is a difference in the mode of floral development. In the first two a single flower ends the primary axis, which is arrested in its growth, and does not elongate. Should more flowers be produced, they arise from separate axes, and they expand after the central flower. In this case, if clusters of flowers are produced, we may observe one flower in the centre fully expanded, a second

farther from the centre only partially expanded, and a

Fig. 125.

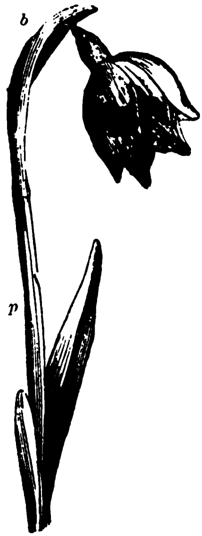


Fig. 126.

Fig. 125.—Flowering stem of the Scarlet Pimpernel or Poor-man's Weather-glass (*Anagallis arvensis*). The floral stem or axis goes on lengthening and producing flowers at the points where the leaves (called floral) join the axis or stem. The lowest flower expands first, and the others in succession upwards. The bracts, in this case, are like the ordinary leaves of the plant, and each bract gives rise to a flower.

Fig. 126.—Flower of Spring Snow-flake (*Leucojum vernum*), supported by a peduncle, *p*, called a scape, and coming out from a sheathing bract, *b*. The flower is drooping and solitary, and the perianth is above the ovary.

third, still farther off, in the state of bud, and so on. The expansion of the flowers is, therefore, what is called centrifugal—*i.e.* going from the centre outwards or downwards. Again, in the latter two instances—viz. the periwinkle and the pimpernel—the floral expansion is different; the flowers are produced laterally on the

Fig. 127.

axis, which elongates and continues to produce flowers in regular succession from below upwards, so that the lowest flowers are first expanded, and the whole inflorescence is on one axis. This development is called centripetal, because the expansion is from below upwards, or, in the case of shortened clusters, from without inwards, always towards the centre of the axis. There are,

Fig. 127.—Flowers of Polyanthus-Narcissus (*Narcissus Tazetta*) bursting from a sheathing bract, *b*. The inflorescence is a definite umbel. Two of the ordinary leaves, *l l*, are also shown.

then, two kinds of inflorescence—one called Determinate or Definite, with centrifugal opening of the flowers; and the other Indeterminate or Indefinite, with centripetal opening of the flowers.

In the dandelion, daisy, and marigold, the heads of flowers are surrounded by a set of bracts arranged in a

Fig. 128.

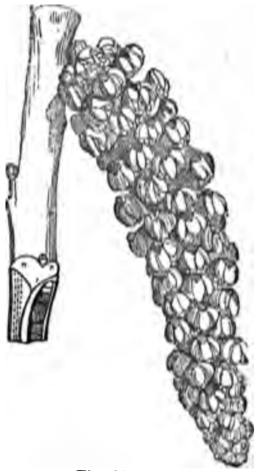


Fig. 129.

whorl or involucre (figs. 130 *b*, 128 *i*). A similar arrangement of bracts is observed in the hemlock tribe. In the willow, the hazel, the oak, the walnut, and other trees which bear catkins, each flower has a scaly bract covering it (fig. 129). Bracts sometimes continue attached to the fruit, as in the oak, hazel, hop, and fir. The cup of the

Fig. 128.—Head of flowers of Marigold, consisting of numerous flowers, *f*, enclosed by bracts, *i*, which form an involucre or covering outside the mass of flowers.

Fig. 129.—Catkin (*Amentum*) of the Walnut, bearing numerous flowers, each of which has a scaly bract at its base.

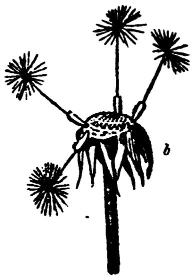


Fig. 130.

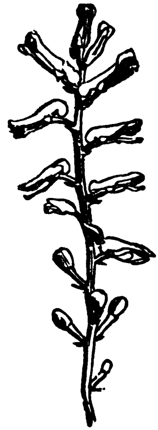


Fig. 131.

Fig. 132.

acorn (fig. 216, p. 154), the husk of the common filbert

Fig. 130.—Receptacle or part of the Dandelion on which the flowers are placed. It is represented in the dry state when the plant is in fruit, and the bracts, *b*, surrounding the head of flowers are turned back so as to allow the fruit to be easily scattered by the wind. The fruit is seen, with the calyx attached and appearing above in the form of hairs or pappus.

Fig. 131.—Peduncle or floral axis of Fumitory (*Fumaria officinalis*), bearing numerous flowers (multifloral). Each flower is attached to the rachis or floral axis by a short stalk called a pedicel, at the base of which a leaflet called a bractlet is produced. The length of this bractlet, as compared with the pedicel of the fruit, is useful in determining the species of fumitory.

Fig. 132.—Butchers-broom, showing leaf-like flower-stalks bearing clusters of flowers.

(fig. 215, p. 154), the scales of the hop-fruit, and those of the cone (fig. 220, p. 155), are bracts.

Some flowers are supported on a stalk called a peduncle, while others have no stalk and are called sessile. A flower-stalk may support one flower, as in the pimpernel and snowflake (figs. 125 and 126), or it may support many flowers, as in the narcissus and the marigold (figs. 127, 128). In the dandelion (fig. 130) the top

Fig. 133.

Fig. 134.

of the peduncle is flattened, so as to form a receptacle for many flowers. In the common red currant, in germander speedwell, and in fumitory (fig. 131), we have instances of elongated flower-stalks having many flowers borne on short stalklets, and arranged alternately. Flower-stalks are broadened like leaves in the butchers-broom (fig. 132), and they become large and succulent in the cashew, where they constitute what is called the cashew-

Fig. 133.—Fruit of Fig. This is a succulent stalk, or peduncle, curved so as to form a hollow receptacle, on which numerous flowers are placed, each bearing a single-seeded fruit resembling a seed.

Fig. 134.—The Wig-tree (*Rhus Cotinus*), so called on account of its flowering stalks bearing hairs in place of flowers. In the figure a solitary flower is shown ; all the rest are abortive.

Fig. 135.

Fig. 137.

Fig. 136.

Fig, 135.—Fruit of Cashew (*Anacardium occidentale*). *p*, enlarged peduncle ; *a*, fruit or nut.

Fig. 136.—Flowering stem of Gentianella (*Gentiana acaulis*). The plant produces a single flower, and it is called unifloral. The termination of the axis, *a*, bears two leaves or bracts, *c*. The flower, *b*, with its calyx and corolla, terminates the axis. This is the simplest form of definite inflorescence. If other axes are produced in such a case, they arise from the axil of the bracts, *c*, and the flowers expand after the central one, *b*, or in what is called a centrifugal manner. Each axis ends in a solitary flower.

Fig. 137.—Flowering stalk of Clove-pink (*Dianthus Caryo-*

apple bearing the fruit or nut (fig. 135). The fig presents a hollow peduncle bearing numerous flowers inside

Fig. 138.

Fig. 139.

(fig. 133). In the wig-tree some of the peduncles bear hairs in place of flowers (fig. 134).

phyllus). The flowers form a fascicle. The inflorescence is definite and centrifugal—the central flower expanding first, afterwards those at *b* and *c*.

Fig. 138.—Spike of Verbena, consisting of sessile flowers, which expand from below upwards (centripetally).

Fig. 139.—Head of flowers of Scabious. The outer flowers open first, and the inflorescence is centripetal—*i.e.* from without inwards to the centre.

In fig. 136 there is shown a flower of gentianella, which terminates the axis and is solitary. It is a simple instance of definite flowering. Should other flowers be produced, they will be developed on separate axes in a centrifugal manner—*i.e.* farther and farther from the central flower, which is the first to expand. In fig. 137

Fig. 140.

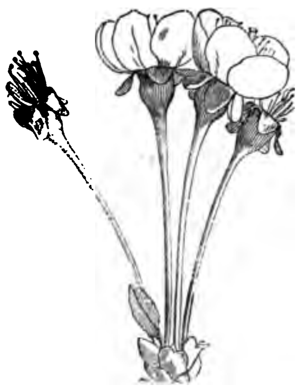


Fig. 141.

there is an instance of a many-flowered definite inflorescence in the carnation. The central flower is shown fully expanded. It terminates the primary axis. The second flower, *b*, is not yet expanded fully. It is produced on a secondary axis farther from the centre; while the flower, *c*, is still less expanded, and is pro-

Fig. 140.—Raceme of Red Currant. Stalked flowers on a lengthened axis. Inflorescence centripetal—*i.e.* from below upwards.

Fig. 141.—Simple umbel of Cherry. Stalked flowers arising from a common point.

duced on a tertiary axis still farther from the centre. These, then, are two cases of definite inflorescence—the first being one-flowered, the second many-flowered.

Fig. 138 is an example of indefinite inflorescence in which the axis elongates and the lower flowers are first expanded—the others being developed in regular succession from below upwards. In fig. 139 there is another form of indefinite inflorescence, in which the axis is shortened and the outer flowers expand first,

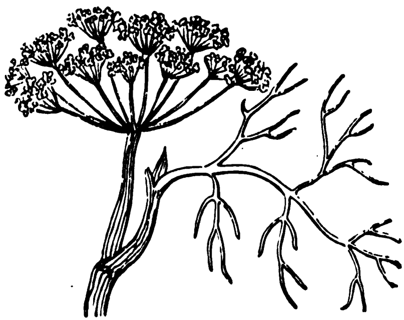


Fig. 142.

while the inner ones expand in succession from without inwards towards the centre—*i.e.* centripetally.

Certain kinds of inflorescence have received names which are much used in the description of plants, and which it is necessary to explain. Numerous stalked flowers placed alternately on a common floral axis constitute a *raceme*, as in the currant (fig. 140). A similar arrangement, in which the flowers have no stalks, is a *spike*, as in common verbena (fig. 138). When the

Fig. 142.—Compound umbel of Common Dill. One primary umbel and numerous secondary umbels.

floral axis is shortened, and numerous stalked flowers come off from the end of a common peduncle, like the radii of a circle, an *umbel* is formed (fig. 141). The umbel is often compound—that is, there is a second umbel formed at the end of each of the stalks (pedicels) coming from the common peduncle, as in many umbelliferous plants (fig. 142). When flowers arise from the end of the common peduncle and have no stalks, but

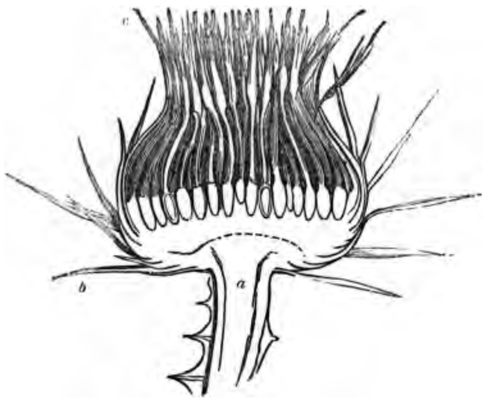


Fig. 143.

are sessile, then a head is formed, as in the dandelion, daisy, marigold (fig. 128, p. 97), and thistle (fig. 143).

A variety of raceme called a *corymb* is produced by the lower flowers having longer stalks than the upper ones on the axis, so that all the flowers are nearly on a level at the summit. The spike, when the axis is fleshy and all the flowers are enclosed in a sheathing

Fig. 143.—Head of flowers of Scotch Thistle. Peduncle, *a*, flattened out at the end and bearing numerous flowers, *c*. Bracts, *b*, surrounding the flowers in the form of an involucre.

bract (spathe), is called a *spadix*, as in cuckoo-pint (fig. 144), and palms; and when the flowers are covered by scaly bracts, as in the willow, hazel, beech, and walnut (fig. 129, p. 97), the name *catkin* is applied.

Fig. 144.

The *cyme* is a form of definite or determinate inflorescence in which more than one floral axis is developed, as in geranium. In the chickweed order floral axes are usually developed in pairs from the pre-existing axes,

Fig. 144.—Spadix or succulent spike of cuckoo-pint (*Arum maculatum*). 1 Exhibits the sagittate leaf, the spathe or sheathing bract, *b*, rolled round the spadix, the apex of which, *a*, is seen projecting. 2 Shows the spathe, *b*, cut longitudinally, so as to display the spadix, *a*. *f*, Female flowers at the base. *m*, Male flowers. On the spadix above the male flowers there are numerous abortive flowers indicated by hair-like projections.

and to this form the name *dichasium* or dichasial cyme is given (fig. 145.) In the Forget-me-not (*Myosotis palus-*

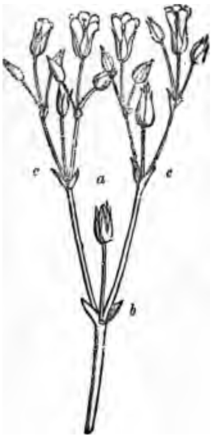


Fig. 145.

Fig. 146.

tris, fig. 146), the inflorescence is at first a dichasium, but on the secondary axes the flowers are produced on

Fig. 145.—Inflorescence (dichasial cyme) of the Mouse-ear Chickweed (*Cerastium tetrandrum*). First axis ends in a single flower, *a*, which opens first. This axis bears two bracts, *b*, each of which gives origin to a secondary axis, each ending in a single flower and bearing two bracts, *c c*, which in their turn give rise to tertiary one-flowered axes. There are thus one primary flower, two secondary, four tertiary, eight quaternary, and so on.

Fig. 146.—Scorpioid inflorescence of Forget-me-not (*Myosotis palustris*). The floral axis arises from a leaf, *c*, and ends in a solitary flower, *a*. From this axis proceed in a forking manner scorpioid racemes, *b b*. The flowers are developed on one side only (unilateral or secund), and the whole inflorescence is curved like the shell of a snail or the tail of a scorpion.

one side only in a racemose manner, the whole being twisted on itself like a scorpion's tail; hence the names scorpioidal applied to the inflorescence and scorpion-grass to the plant.

Figs. 147, 148, and 149 show the different modes

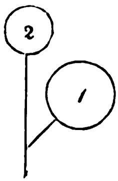


Fig. 147.

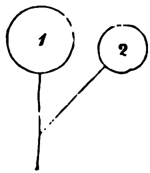


Fig. 148.

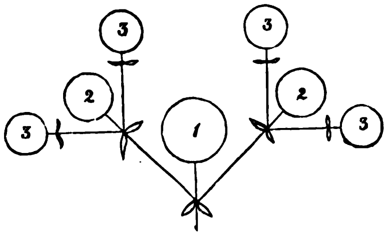


Fig. 149.

of inflorescence. Fig. 147 shows indefinite inflorescence, in which the lower floret (1) expands first, and then the upper floret (2). Fig. 148 shows definite inflorescence, where the terminal floret (1) opens first, and then the lower floret (2). Fig. 149 shows definite inflorescence with numerous floral axes. The first floral axis bears a flower (1), which opens first; then come off two floral axes (2 2), the flowers of which expand next; then each of these gives off two floral axes (3 3, 3 3), which expand third in order, and so on.

Figs. 147, 148, 149.—Forms of indefinite and definite inflorescence.

QUESTIONS.

1. What are the organs of reproduction in flowering plants?
2. What is meant by phanerogamous plants?
3. What is meant by cryptogamous plants?
4. What is the meaning of inflorescence?
5. What are bracts?
6. What is meant by a spathe? Give an example.
7. Mention some of the forms which bracts assume.
8. Describe indefinite inflorescence.
9. What is meant by the centripetal expansion of flowers?
10. Describe definite inflorescence.
11. What is meant by the centrifugal expansion of flowers?
12. What kind of bracts occur in palms?
13. What are glumes?
14. What arrangement of bracts is seen in the dandelion and the daisy?
15. What is meant by the term involucre?
16. What is a peduncle?
17. What is meant by the receptacle of the flowers?
18. What kind of flower-stalk occurs in the butchers-broom?
19. Describe the peduncle of the cashew and of the fig.
20. Describe a raceme and a corymb, and give an example of each.
21. Describe an umbel, and give an example.
22. Describe a head of flowers, and give an example.
23. Describe a spike and a spadix, and give an example of each.
24. Describe a catkin, and give an example.
25. What is meant by a cyme? Give an example.
26. Describe scorpioidal inflorescence, and give an example.
27. What is meant by a dichasium or dichasial cyme? Give an example.

II.—The Flower and its Parts.

Floral Symmetry.—The parts of the flower are usually arranged in four series, or whorls—that is to say, in four sets of leaves or modified leaves arranged in alternating rows,—1. The calyx, 2. the corolla, 3. the stamens, 4. the pistil. These parts are seen in figs. 150 and 151, in which *c* is the calyx, *p* the corolla, *s* the stamens, and *b* the pistil. In fig. 150 the differ-

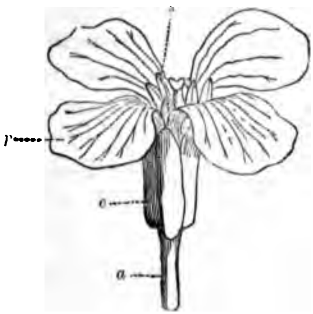


Fig. 150.

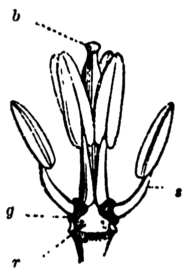


Fig. 151.

ent series of the flowers are complete; in fig. 151 the calyx and corolla are removed. These parts are looked upon as leaves altered to suit the particular functions which each row performs, and sometimes appear in the form of true leaves without any marked modification. The inner two of the series are essentially connected with the production of seed, and are

Fig. 150.—Flower of Common Wallflower. *a*, The flower-stalk, *c*, the calyx, *p*, the corolla, *s*, the stamens.

Fig. 151.—Same flower with calyx and corolla removed. Stamen, *s*, pistil, *b*—its upper part called the stigma, *r* the receptacle to which the parts of the flower are attached, *g* a small gland at the base of the stamen.

called essential organs (fig. 151). The outer two are protective and nutritive organs, and are called floral envelopes. When flowers become double, the stamens and pistil are more or less completely changed into parts resembling the outer series, and when the alteration is complete no seed is produced. In the eyes of a florist the more perfect the change the finer is the flower; while the botanist looks upon such flowers as monstrous, and imperfect as regards the function of reproduction. Double flowers, such as the camellia, often show well the spiral arrangement and alternation of the parts.

The parts of each series or whorl are arranged like leaves on the principle of alternation, and there is an evident symmetry as regards the number of the parts. The numbers which generally prevail in the flower are 2, 3, and 5, or multiples of them. Thus, if a flower has 5 parts of the calyx, it has usually 5 of the corolla alternating with them; 5, 10, or 20 stamens; and 5, or some multiple of 5, in the parts of the pistil. So also with those flowers which have 2 or 3 parts in the calyx. In fig. 152 a diagram is given showing the alternation of the 5 parts of each whorl of the flower. It is worthy of notice that flowers exhibiting 2 or 5, or multiples of these numbers, in their whorls, usually belong to plants having two seed-lobes or cotyledons, and which, when they form permanent woody stems, exhibit distinct zones or circles, and are exogenous; while flowers having 3, or a multiple of 3, in their whorls, present only one seed-lobe, and when they form permanent woody stems exhibit no distinct zones or *circles*, and are endogenous. The number 2, or a mul-

tiple of it, is seen also in the parts of fructification of flowerless plants which have no seed-lobes, such as ferns, mosses, and seaweeds. The processes which project from the urn-like cases of mosses are arranged in the series 4, 8, 12, 16, 32, 64, etc. The parts of fructification of scale-mosses (*Jungermanniæ*) are in fours, as also the germs of some seaweeds. In general the numbers 2, 3, and 5 prevail, with their multiples, and we have thus the leaf-series 2, 3, 5, 8, as mentioned at page 58.

Fig. 152.

Fig. 153.

Fig. 154.

The parts forming the individual flower are arranged in a whorled manner, but in reality each whorl is a complete spiral cycle, the coloured leaves of which are placed closely together. Each separate whorl, or whorled cycle, alternates with that next to it. The

Fig. 152.—Diagram to show the arrangement of the parts of the flower. There are 4 whorls, each consisting of five parts, which alternate with those next them.

Fig. 153.—Irregular gamopetalous wheel-like corolla of Speedwell (*Veronica*). The irregularity consists in the different sizes of the lobes of the corolla, especially the lower lobe, *l*, which is much smaller than the rest. The stamens are two, and the style one, so that the flower is Diandrous and Monogynous.

Fig. 154.—Irregular gamopetalous labiate corolla of the Dead-nettle (*Lamium album*). The upper lip, *u*, is composed of two petals united, the lower lip, *l*, of three. Between the two lips (labia) there is a gap (hiatus). The throat is the part where the tube and the labiate limb join. On account of the arching of the upper lip this corolla is called ringent.

arrangement of the parts of the flower of a plant does not always correspond with that observed in the leaves. Thus in the Iris the leaves of the creeping stem have a divergence of $\frac{1}{2}$, while in the flower the number is $\frac{2}{3}$. In Gentianella the leaves are in pairs at right angles to each other, while the floral leaves have a divergence of $\frac{3}{5}$. There is sometimes a difference also in the numbers expressing the divergence of the different whorls of the same flowers.

There is frequently an interference with the law of symmetry in the flower by adhesion, by abortion, or by non-development of parts. The symmetry of a flower must be viewed to a certain degree independently of its regularity or irregularity of form. Symmetry has reference to number and arrangement of parts, regularity to size and appearance. A flower may be irregular in its form, and yet its parts may be symmetrical. Thus the common veronica or speedwell (fig. 153) is irregular in its corolla, some parts being larger than others, yet the numbers 2 and 4 prevail in the flower—viz. 4 parts of the calyx, 4 of the corolla, 2 stamens, and 2 parts of the pistil. We often notice, however, that any cause which gives rise to want of symmetry also causes irregularity in form. By cohesions of various kinds there appears to be sometimes an interference with the proper number of parts in a whorl. Thus, in labiate or lipped plants there are two lips of the corolla, and thus apparently only two parts, but in reality there are five, of which two cohere to form the upper lip, and three the lower (fig. 154). In slipperwort (*Cypripedium*) there are two in place of three parts of the calyx, in consequence of the cohesion of two. Non-development is a constant cause of want of

symmetry. The corolla is sometimes absent, and then

Fig. 155.

Fig. 156.

the flower has only one covering, and is called mono-

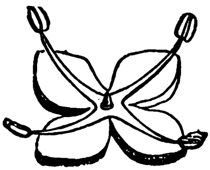


Fig. 157.

Fig. 158.

chlamydeous (figs. 155, 157). In such a case the stamens

Fig. 155.—Flower of Pellitory (*Parietaria officinalis*). It contains four stamens, the filaments of which are incurved in the early state, and ultimately bend back with elastic force, so as to scatter the pollen, *s*. There are four divisions of the perianth, or floral envelope, *c*. The flower is monochlamydeous. The rudiment of a pistil is seen in the centre.

Fig. 156.—Flower of Euphorbia. The whole flower consists of a stamen, *b*, supported on a peduncle, *p*, to which it is united by an articulation at *a*. The flower is naked (achlamydeous). In some Euphorbias a perianth, or floral envelope, appears at the joint.

Fig. 157.—Staminate or staminiferous flower of Mulberry (*Morus nigra*), showing a four-partite calyx, and four stamens with long filaments and two-lobed anthers. The flower is monochlamydeous, from absence of the corolla, and the stamens are opposite (superposed to) the segments of the perianth on account of the suppression of the corolline whorl.

Fig. 158.—Pistillate or pistilliferous flower of the Nettle (*Urtica*), consisting of a two-leaved perigone, or floral envelope, *p*, with a single pistil. The pistil consists of an ovary, and a sessile tufted stigma, *s*.

are placed opposite to, or superposed to, the parts of the whorl next them, in place of being alternate. A scale or scales may occupy the place of calyx and corolla; and sometimes there is a complete want of both these parts (fig. 156). In a perfect flower stamen and pistil are present, but if these organs are in separate flowers, we have a flower bearing stamens and no pistil, and called staminate, as in fig. 157, or a flower bearing a pistil and no stamens, and called pistillate (fig. 158).

These varieties may be represented thus—the line (—) indicating the presence of a part, while the letter 0 marks its absence :—

1. Perfect flower, with five parts in each whorl (pentamerous symmetry)—Dichlamydeous.

Calyx (5 sepals)	—		—		—		—	
Corolla (5 petals)		—		—		—		—
Stamens (five)	—		—		—		—	
Pistil (5 carpels)		—		—		—		—

2. Pentamerous flower, having no corolla—Monochlamydeous.

Calyx	—		—		—		—		—	
Corolla		0		0		0		0		0
Stamens	—		—		—		—		—	
Pistil		—		—		—		—		—

3. Pentamerous flower, with no floral envelopes—Achlamydeous.

Calyx	0		0		0		0		0	
Corolla		0		0		0		0		0
Stamens	—		—		—		—		—	
Pistil		—		—		—		—		—

4. Pentamerous flower, having stamens only—Staminate; no envelopes and no pistil.

Calyx	0		0		0		0		0	
Corolla		0		0		0		0		0
Stamens	—		—		—		—		—	
Pistil		0		0		0		0		0

5. **Pentamerous flower, with pistil only—Pistillate ; no envelopes and no stamens.**

Calyx	0		0		0		0		0	
Corolla		0		0		0		0		0
Stamens	0		0		0		0		0	
Pistil		—		—		—		—		—

In many such flowers the non-developed part required to complete the symmetry is present in an imperfect state. Often in pistilliferous flowers of the red campion partially-developed stamens are seen, while in the staminiferous flowers an imperfect pistil is detected. Some cases of partial development help to confirm the law of symmetry. Thus in Gloxinia the envelopes are in five parts, but there are only four stamens. On close examination, however, the fifth stamen is seen in the form of a small projecting point. That this is in reality an abortive stamen is proved by it occasionally becoming perfect under cultivation. Along with this perfecting of the fifth stamen, the corolla also, in place of being irregular and inclined, becomes regular and erect.

The symmetry of the pistil and fruit is often interfered with. Certain parts become abortive, and some increase at the expense of others, especially when they become fleshy. Thus in the olive the symmetry is dimerous, or of two parts, but there is only one part in the ripe fruit. In the coco-nut the symmetry is trimerous, or represented by the number 3 ; in the ripe fruit, however, there is a single cavity and one seed, the other two being abortive. This abortion is proved by examining the shell of the coco-nut, in which there are three evident ridges indicating the three original parts.

By careful examination we can often account for

apparent anomalies. Thus in the fumitory (fig. 131, p. 98) there are two parts of the calyx, four of the corolla—that is, two and two—and six stamens. The latter, however, are found to be in reality four, inasmuch as two of them are formed each by a split stamen. It is represented thus—the long line indicating a complete part, the short lines indicating that the part is split into two :

Calyx,	———		———	
Corolla, 1st row,		———		———
Do., 2d row,	———		———	
Stamen, 1st row,		———		———
Do., 2d row,	— —		— —	

Times of Flowering.—The flowering of plants takes place at different periods of the year, and thus a calendar of the seasons may be constructed. By observing the exact time when plants in the same garden flower in different years, an indication will be given of the nature of the season. The mezereon and snowdrop, hepatica and winter aconite, put forth their flowers in February in this country, the primrose and crocus in March, the cowslip and daffodil in April, the hawthorn in May, the great mass of plants in May and June, many in July and August, the ivy in September, the meadow-saffron and strawberry-tree in October and November, and the Christmas rose in December. Some plants, like the daisy, produce their flowers throughout the whole season.

Besides annual periods, some flowers exhibit diurnal periods of expansion and of closing. On this fact Linnæus constructed what he called a floral clock, in which each hour of the day was marked by the opening of some flower. While most flowers open during the *day,* there are some which expand their flowers in the

evening, and are called night-bloomers. To that class belongs the night-flowering cereus (*Cereus grandiflorus*), a kind of cactus which unfolds its flowers about nine or ten o'clock at night.

The closing of flowers also follows a periodical law. Most flowers close during darkness. Some close even in daylight. Thus the salsafy shuts up its heads of flowers about mid-day, and the chicory about four in the afternoon. Many flowers are affected by the nature of the day as regards moisture, dryness, cloudiness, or clearness, and are called meteoric. In cloudy and rainy weather the flowers of the scarlet or "pink-eyed pimpernel," called poor man's weather-glass (fig. 125, p. 95), remain closed. So also do the heads of flowers of the daisy, dandelion, and other composite plants. By this means the essential organs of the flower are protected from injury. The direction of the flowers of some plants seems to be influenced by the sun's rays; and the name girasole, or sunflower, was given from an impression that the heads of flowers inclined towards the part of the heavens where the sun was shining. This does not, however, appear to be the case with the sunflower as grown in this country. One of the species of girasole is the plant called Jerusalem artichoke. The first part of the name is a corruption of girasole, and the latter is given from the taste of the roots being like that of the common artichoke.

QUESTIONS.

1. What are the parts of the flower?
2. What is meant by the essential organs of the flower?
3. What is meant by the floral envelopes?

4. How do flowers become double ?
5. What numerical series do the parts of the flower follow ?
6. What numbers prevail in the flowers of exogens ?
7. What number prevails in the flowers of endogens ?
8. What number is conspicuous in flowerless plants ?
9. What is meant by symmetry in flowers ?
10. How is floral symmetry interrupted ?
11. What is the meaning of superposed organs ? Give an example.
12. What is meant by a symmetrical flower ? Give an example.
13. What is meant by an unsymmetrical flower ? Give an example.
14. What is meant by a regular flower ? Example.
15. What is meant by an irregular flower ? Example.
16. What is meant by a dichlamydeous flower ? Give an example.
17. What is meant by a monochlamydeous flower ? Give an example.
18. What is meant by an achlamydeous flower ? Give an example.
19. What is meant by a staminate flower ? Example.
20. What is meant by a pistillate flower ? Example.
21. Explain the meaning of a pentamerous flower.
22. Explain the meaning of a trimerous flower.
23. Describe a labiate corolla, and give an example.
24. Describe the flower of the veronica (common speedwell).
25. Mention the parts of the flower in wallflower.
26. How is a floral calendar formed to indicate the months of the year ?
27. How is a floral clock formed to indicate hours of the day ?
28. Give an instance of a plant expanding its flowers late in the evening.
29. What is meant by meteoric flowers ?
30. Whence does the sunflower derive its name ?

Æstivation.—The arrangement of the parts of the flower in the flower-bud is called æstivation, and it follows the same law as we have already seen to regulate the leaves in the leaf-bud—the parts being either applied laterally to each other, or folded or rolled up in different ways. Sometimes the parts overlap each other like the tiles of a house, at other times they are twisted upon each other, as in the mallow. Each flower has its own kind of æstivation.

The Calyx.—This is the outer covering or envelope of the flower. It is usually of a greenish hue like


Fig. 159.

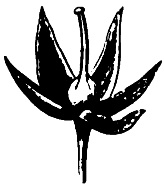


Fig. 160.


Fig. 161.

leaves. Sometimes, however, it is coloured, as in the fuchsia and Indian cress. It consists of a certain number of parts called sepals, which are either distinct from each other, when the calyx is polysepalous, as in the common buttercup and wallflower (fig. 150, p. 109), or

Fig. 159.—Gamosepalous five-toothed (quinque-dentate) calyx of Campion (*Lychnis*).

Fig. 160.—Gamosepalous five-partite (quinque-partite) calyx of Pimpernel (*Anagallis*), surrounding the pistil, which is composed of ovary, style, and stigma.

Fig. 161.—Bilabiate gamosepalous (monosepalous, synsepalous) calyx of the Dead-nettle (*Lamium*). It is composed of two lips, the upper lip formed by three sepals, the lower by two. One of the upper sepals stands prominently out from the rest. The tube is formed by the united sepals, the free part of the calyx forming the limb, and the opening being the faux or throat.

are united together more or less completely, when the calyx is gamosepalous (monosepalous), as in the harebell,

Fig. 162.

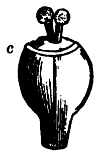


Fig. 163.

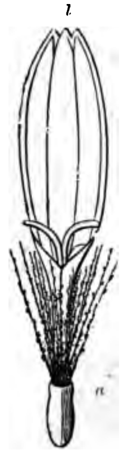


Fig. 164.

gentianella, dead-nettle, and campion (fig. 159). The calyx is either regular—that is, has all its parts or sepals equal, as in the pimpernel (fig. 160); or it is irregular—

Fig. 162.—One of the central flowers of the Sunflower (*Helianthus*). The corolla is gamopetalous, five-toothed at the apex, the calyx is adherent to the fruit, and the limb of the calyx appears above the fruit in the form of a membrane, with pointed projections. The calyx, *c*, is called superior, because it is above the fruit. Extending beyond the corolla are seen the stamens and pistil.

Fig. 163.—Calyx, *c*, of Madder (*Rubia*) attached to the pistil, appearing above it in the form of a rim. The calyx is called obsolete.

Fig. 164.—Irregular gamopetalous (monopetalous, sympetalous) ligulate flower of Ragwort (*Senecio*). It is a tubular floret, split down on one side, with the united petals forming a strap-like projection, *l*. The lines on the flat portion indicate the divisions of the five petals. From the tubular portion below, the bifid style projects slightly. The fruit (achænium), *a*, is surmounted by hairs *(pappus), which* are the metamorphosed calyx.

that is, has its parts unequal, as in the dead-nettle (fig. 161), and in larkspur where it is spurred, and in monkshood where it is like a hood. The calyx, in the case of the gooseberry, currant, cucumber, pear, apple, pomegranate, sunflower (fig. 162), and many other plants, forms a covering of the fruit, and remains attached to it when ripe. In such cases the limb of the calyx is placed above the ovary. In some instances the calyx falls off very early, as in the poppy. In some plants the calyx is inconspicuous, and is reduced to a mere rim or slight projection, as in hemlock, and in certain rhododendrons, and in madder (fig. 163). In plants, such as the thistle and dandelion, which belong to the large division called composites, having numerous small flowers on a common head, the calyx is united to the fruit, and appears at the upper end of it in the form of hairs or pappus (fig. 164). This hairy condition of the calyx is made subservient to the scattering of the seed (fig. 130, p. 98), and in the case of thistles is the means of diffusing extensively these noxious weeds.

The Corolla.—This is, generally speaking, the showy part of the plant, in which the gay colours of the flower reside. It is sometimes wanting, as in nettles, willows, and catkin-bearing trees, such plants having only a calyx or bracts covering the essential parts of the flower. When present it consists of a number of leaves called petals, which are either distinct from each other, when the corolla is polypetalous, as in the buttercup, wallflower, cinquefoil, rose, and stonecrop (fig. 165), or united together in various ways, when it is gamopetalous, as in the gentian (fig. 136, p. 100), foxglove, frogs-

mouth, dead-nettle, and harebell (fig. 166). A corolla is regular when its petals or its lobes are of equal size, as in the strawberry (fig. 167), which has separate petals, and in the harebell (fig. 166), which has united

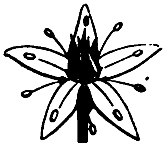


Fig. 165.


Fig. 166.

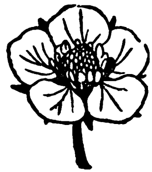


Fig. 167.

petals; and it is irregular when the petals or the lobes of the corolla are of unequal size, as in the pea, speedwell, and dead-nettle (figs. 171-173; 153, 154, p. 111). Some irregular corollas, especially those of orchids, present curious forms, resembling insects, such as butterflies, bees, and spiders.

The petals are composed of a congeries of minute cells, each containing colouring matter, and delicate spirals interspersed, all being covered by a thin epidermal coat or skin. The coloured cells are distinct from one another, and thus a dark colour may be at one part and a light colour at another. One of the most beautiful objects under the microscope is the petal of a pelargonium.

Fig. 165.—Polypetalous corolla of Biting Stonecrop (*Sedum acre*). It is composed of five separate petals, and hence is pentapetalous. There are ten stamens in two rows, and five carpels.

Fig. 166.—Regular gamopetalous bell-shaped (campanulate) corolla of Harebell (*Campanula rotundifolia*). It is composed of five petals united. The ovary is inferior, and is united to the calyx, *c.* Calyx superior (epigynous).

Fig. 167.—Rosaceous corolla of the Strawberry (*Fragaria vesca*), composed of five petals without claws. The points of the calyx are *seen alternating* with the white petals.

Petals assume various forms; some are flat, others folded, or hollowed in various ways. In the carnation there is a long narrow portion called the claw; in mignonette the petal is divided into segments (fig. 168); in columbine the petals are hollow, and form a long

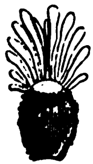


Fig. 168.

Fig. 169.

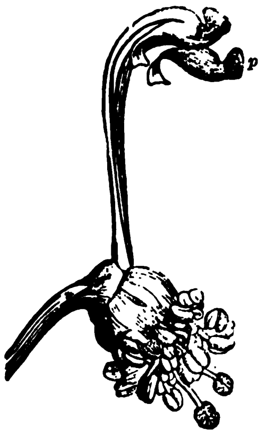


Fig. 170.

Fig. 171.

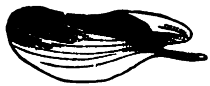


Fig. 172.

Fig. 173.

spur at the base (fig. 169); in monkshood two of them are hollow and raised on long stalks (fig. 170, *p*); they are concealed under the hood-like sepal. There are

Fig. 168.—Petal of Mignonette divided at the apex into numerous narrow segments.

Fig. 169.—Horn-like hollow petal of Columbine.

Fig. 170.—Two peculiar horn-like stalked petals, *p*, of Monkshood. Below the petals are seen numerous stamens attached to the receptacle.

Fig. 171.—Standard (vexillum) upper petal of a papilionaceous flower (blossom like that of the pea).

Fig. 172.—One of the wings (alæ) or side petals of a papilionaceous flower.

Fig. 173.—Keel (carina) of papilionaceous flower. It is formed of two petals.

certain forms of corolla which deserve notice. Among polypetalous corollas some are regular, as the rose and strawberry (fig. 167); others are irregular, as the pea. In the wallflower (fig. 150, p. 109) there are four petals arranged like a cross, and hence the corolla is called cruciate. In the pea the flower is called papilionaceous (butterfly-like); it consists of a large upper enveloping petal called the standard (fig. 171), two side ones called wings (fig. 172), and a boat-shaped body called the keel (fig. 173), formed by two cohering petals which enclose the essential organs.

In orchids the floral envelopes are in two rows, both coloured, each consisting of three parts, the outer being the calyx, and the inner the corolla. One of the petals of the latter has usually a marked form, and is called the label (lip), (fig. 192, *l*, p. 140).

Among gamopetalous (monopetalous) corollas there are also regular and irregular forms. In the harebell, the corolla is regular and bell-shaped (fig. 166, p. 122); the central yellow flowers in the head of the daisy are tubular and regular, while the outer white flowers are ligulate and irregular (fig. 164, p. 120). In the pimpernel, the corolla is regular and wheel-shaped (fig. 125, p. 95); in the speedwell, irregular and wheel-shaped (fig. 153, p. 111). In the dead-nettle, there is an irregular-lipped corolla (fig. 154, p. 111).

Appendages to the corolla are seen in the fringes of the passion-flower, in the crown of the narcissus, and in the scales of the comfrey. These are modifications of parts of the flower, more especially of the petals and stamens. They have sometimes received the name of *nectaries.*

Colours of Flowers.—The colours of flowers are arranged in two series, the yellow and the blue. A plant belonging to the yellow series may exhibit all the tints of white, yellow, and red, but it does not appear to have the power of becoming blue. So also with a plant of the blue series; it too may exhibit varying tints of white and red and blue, but generally refuses to become yellow. The tulip, the dahlia, and the rose belong to the yellow series; and while, by cultivation, they exhibit innumerable changes, yet they have not been made blue. The common harebell belongs to the blue series, and is not seen to assume the yellow. Such appears to be the general law, although there are, no doubt, some apparent exceptions, especially in cases (as the pansy) where blue and yellow occur in the petals of the same flower. But it remains to be proved that a truly yellow petal can be changed into blue by the art of the gardener.

Blue can pass into red by means of acids, and can present all the colours resulting from the mixture of blue and red. Yellow is capable of reddening by oxygenation (*i.e.*, by the action of oxygen), and also by acids (as in the yellowish juice of some cells of the leaves of red cabbage), and hence yellow flowers may pass to red, and present all the intermediate shades. The red colour, however, of the blue and yellow series is not the same. That of the yellow series seems to be less common in leaves than in flowers; that of the blue series is the reverse. The two kinds of red (one belonging to the blue and the other to the yellow) are sometimes united in the same flower, which may thus

present every imaginable variety of colour. This, however, is a rare occurrence.

It has been observed that the colours which unite in forming the white light of the sun's ray may be reduced to three—red, yellow, and blue. These have been called primary colours. Each of these primaries requires the other two in order to form a white colour. Hence the latter are called complementary, being necessary to make up the complement of colours in white light. Thus, red has green (made up of blue and yellow) for its complementary colour; blue has orange (made up of yellow and red); and yellow has purple (made up of red and blue).

Dr. Dickie has devoted attention to the colour of flowers, whether regular or irregular, and the following is the result of his observations:—"The primary colours, as red, yellow, and blue, are generally present in some part or other of the plant. In regular corollas the colour is uniformly distributed, whatever be the number of colours present. That is, the pieces of the corolla being all alike in size and form, have each an equal proportion of colour. In the primrose there is one colour, uniformly distributed. In the Chinese primrose there are two, the eye or centre being yellow, and the margin showing the complementary colour purple. Each of the parts, in the latter instance, has an equal proportion of yellow and purple. Again, irregularity of corolla is associated with an irregular distribution of colour. An odd lobe or petal of such a corolla is often as much varied in colour as it is in form and size. This difference is seen in some pea-blossomed

flowers, in the lip of some labiate plants as galeopsis, and in the violet. In composite plants, as asters, daisies, etc., there are two forms of corolla; one in the centre, regular and of one kind of colour, and the other in the margin or ray, irregularly and differently coloured."*

Chevreul has made some interesting observations on the simultaneous contrast of colours. He remarked, that when two coloured objects, say red and green, are placed side by side, or so near to each other as to be seen together, the quality and intensity of the separate colours do not appear the same as when looked at separately. Thus the same red object will have a different hue if seen side by side with a green, with a yellow, and with a blue object, and these colours will in their turn be modified to the eye by their juxtaposition with red. A similar statement may be made as regards shades or tints of the same colour when placed together.

Contrast of colour occurs according to the principle that every colour adds its complementary to the colours placed near or beside it. Thus, red causes the colours near it to appear as if its complementary green were added to them. Green tints them with red; blue adds to other colours orange; yellow adds to them purple. The reason why complementary colours, such as red and green, in flowers give pleasure is, because each exalts the other, so that the red makes green greener, and green makes red redder, than either would appear alone. The eye is gratified with the full colours in these cases, not in virtue of some vague recognition of comple-

* M'Cosh and Dickie on "Typical Forms."

mentary colours, but because by no other arrangement can two colours be made to show so fully and richly.*

Odours of Flowers.—The fragrance and odours of flowers reside generally in the petals. These are owing to volatile matters which are not easily detected, the subtile particles of which are diffused through the air in a way which eludes the researches of man. Some colours are associated frequently with certain kinds of odours. Thus dark brown flowers, such as those of stapelias (fig. 174), have usually very fetid and disagreeable odours. Hence they are called carrion-flowers,

Fig. 174.

and are noted for attracting flies, which probably serve an important purpose, as will be afterwards shown, in the production of the seed. Sunshine has in general a marked effect in developing the odours of flowers. Hence in those climates where the sun displays all its brightness, the air is perfumed with fragrant odours. In many cases, alternate showers and sunshine bring out par-

Fig. 174.—Flower of Stapelia, having a very fetid odour, and hence called carrion-flower.

* "Edinburgh New Philosophical Journal," New Series, vol. i. p. 168.

ticular odours; and in some instances the perfumes are intermittent, and are only given out during the night.

The plants called *tristes*, or sad, by Linnæus, including the night-smelling stock and pelargonium, are of this nature, and so are several night-flowering species of cereus. The odour of the latter plants seems to be in a certain measure intermittent, and comes out in puffs every half-hour from eight in the evening till midnight. Morren states that on one occasion the flower of *Cereus grandiflorus* began to expand at six o'clock in the evening, when the first fragrance was perceptible in the hothouse. A quarter of an hour afterwards the first puff of odour took place, after a rapid motion of the calyx; at twenty-three minutes past six there was another powerful emanation of fragrance; by thirty-five minutes past six the flower was completely open; at a quarter to seven the odour of the calyx was the strongest, but modified by the petals.

QUESTIONS.

1. What is meant by æstivation?
2. What kind of æstivation occurs in the mallow?
3. What is the calyx? Of what parts is it composed?
4. What is meant by a monosepalous calyx?
5. What is meant by a polysepalous calyx?
6. What is meant by a regular and an irregular calyx?
7. If there is only one floral envelope, which part does it represent?
8. What is meant by a coloured calyx? Give an example.
9. What is meant by a pappose calyx? In what plants is it observed?
10. What is meant by an obsolete calyx? Give an example.

11. What is meant by an inferior, and what by a superior, calyx? Give examples.

12. What is the inner floral envelope?

13. What are petals?

14. When is a corolla called gamopetalous? Give an example.

15. When is a corolla called polypetalous? Give an example.

16. When the corolla is wanting, what is the flower called? Give an example.

17. What is meant by a regular corolla? Give an example.

18. When is a corolla called irregular? Give an example.

19. What is the claw of the petal?

20. What is meant by a spurred petal? Give an example.

21. What kind of petals are seen in monkshood?

22. What are the parts of a papilionaceous corolla? Give an example.

23. What is meant by a cruciate corolla? Give an example.

24. What is meant by a labiate corolla? Give an example.

25. Mention a peculiarity in the petals of mignonette.

26. What is the part of the corolla called a label in orchids?

27. Describe a ligulate corolla, and give an example.

28. What is meant by nectaries? Give an example.

29. What series of colours are met with in flowers?

30. To which series are the rose, and dahlia, and tulip referred?

31. To which series does the harebell belong?

32. In what tissues is the colouring matter of the corolla formed?

33. To what are the odours of flowers due?

34. What kind of odour usually proceeds from brown flowers?

The Stamens.—These form the third series of parts in the flower (fig. 152, p. 111). In fig. 175 they are numerous, and surround the central pistil, which is longer than the stamens. Like the other parts of the flower, they are considered as a modification of leaves. In double flowers they are converted into petals. They consist usually of two parts, a stalk or filament (fig. 176, *f*) supporting two small cellular bags at the top (fig. 176, *a*), which are called the anther-lobes; when

Fig. 175.

Fig. 176.

there is no stalk the anther is sessile. The anther contains a powder (fig. 176, *p*), often of a yellow colour, called pollen, which is essential to the production of perfect seed in flowering plants. At a certain period of growth, this powder is discharged from the anther, which opens by slits (fig. 176), or by hinges, as in the barberry and laurel, or by holes, as in the heath, rhododendron, and potato, to allow its escape. The anther has two coverings, the inner of which often contains elastic spirals, which seem to assist in the opening of the

Fig. 175.—Flower of Celandine. The calyx has fallen off, the four petals are seen, numerous stamens and one pistil in the centre.
Fig. 176.—A stamen consisting of filament, *f*, anther, *a*, and pollen, *p*, discharged from slits in the anther-lobes.

lobes. The pollen, or the dust of flowers, when examined by the microscope, presents multiplied forms. It must be applied to the pistil or central part of the flower, in order that the seed may be perfected.

The position of the stamens in relation to the ovary requires special attention. Sometimes they are attached to the receptacle—*i.e.* the upper part of the flower-stalk —and are then placed below the ovary and free from it, as well as from the calyx. In that case they are called hypogynous, which means under the ovary (fig. 177).

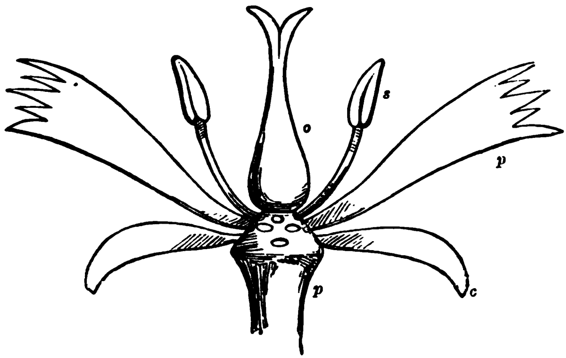


Fig. 177.

Again, the stamens are attached to the calyx to a greater or less extent, but free from the ovary—*i.e.* not adhering to it—and then they are perigynous, which means around the ovary (fig. 178).

A third variety is that in which the stamens appear above the ovary, and are called epigynous, which means

Fig. 177.—End of peduncle, *p* (receptacle or thalamus), bearing sepals, *c*, petals, *p*, and stamens, *s*, all separate and all below ovary, *o* (stamens hypogynous).

upon the ovary. In this case the calyx is attached to the ovary, and is epigynous (fig. 179).

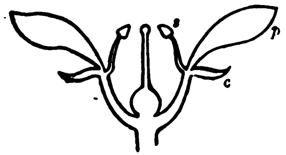


Fig. 178.

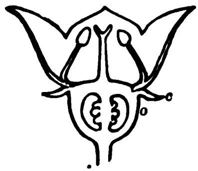


Fig. 179.

The stamens, as regards number, bear a relation to the other parts of the flower. They are either equal to the number of parts in the calyx or corolla, or some multiple of them. When there is a want of correspondence as regards number, it will be found that this depends usually on something abnormal. Thus, in irregular-lipped plants (fig. 154, p. 111), there are five parts of the calyx and five of the corolla, but frequently only four stamens, on account of one stamen being undeveloped. The stamens in such cases are usually of different lengths—two being long and two short, and the name didynamous is given (fig. 180). In cruciform plants there are four long and two short stamens, and the name of tetradynamous is applied (fig. 151, p. 109). The number of the stamens is taken into account in the Linnæan or artificial system of classification, the Greek numerals being prefixed to the term *andria*, meaning stamen (see *Classification*, p. 207). The stamens, like the

Fig. 178.—Figure showing two stamens, *s*, united to the calyx, *c*, and thus surrounding the ovary, which is free in the centre (stamens perigynous). Petal, *p*.

Fig. 179.—Figure showing two stamens placed above the ovary *o*, and therefore epigynous. Calyx, *c*, is also epigynous.

sepals and petals, may be either separate or united. The union of the stamens may take place by means either of their filaments or of their anthers. When the stamens are united by their filaments so as to form one bundle or brotherhood, they are called monadelphous (fig. 181); when there are two bundles, they are diadelphous, as

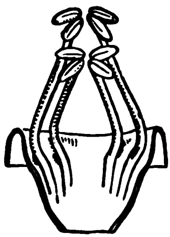


Fig. 180.

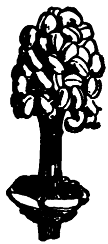


Fig. 181.

in the sweet pea (fig. 182), and in the fumitory (fig. 131, p. 98); and when there are more than two bundles they are polyadelphous, as in St. John's wort (*Hypericum*). Some think that in the last mentioned case there are flattened expansions from the receptacle, each bearing many stamens. When the union of stamens takes place by the anthers, the stamens are syngenesious or synantherous, as in the dandelion, and in composite plants generally (fig. 183); when the stamens and pistil are united on a column, the term gynandrous is applied, as in orchids (fig. 192, p. 140), and in birthwort (fig. 184). The filament is sometimes long and thread-like,

Fig. 180.—Two long and two short stamens of Foxglove. They are didynamous, and are attached to the corolla.

Fig. 181.—Stamens of Mallow united by their filaments so as *to form one* bundle (monadelphous). The anthers are not united.

as in grasses (fig. 185); at other times it is short and thick; at times it is elastic, and sometimes irritable.

Fig. 183.

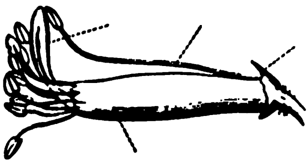


Fig. 182.

Fig. 184.

The pollen consists of minute cells contained in the anther-cases. Sometimes they are united in fours, at other times in masses, as in orchids (fig. 186). The pollen must be applied to the pistil in order to insure the formation of perfect seed containing the embryo plant inside.

Fig. 182.—Stamens of Sweet Pea united in two bundles by their filaments. In this case there are ten stamens, nine of which are united, and one is free. They are diadelphous.

Fig. 183.—Tubular corolla of Ragwort (*Senecio Jacobæa*) showing united anthers surrounding the style (syngenesious or synantherous). The single-seeded ovary, *o*, is surmounted by the hairy limb of the calyx (pappus). Bifid stigma, *s*.

Fig. 184.—The stamens and pistil, *a*; the former placed below the part of the latter called the stigma; *b*, inferior ovary; seen in birthwort (*Aristolochia*).

Many beautiful arrangements are made for insuring the proper application of the pollen to the upper part of the pistil. The agency of winds, of elasticity, of irritability, and of insects, is called into operation in

Fig. 185.

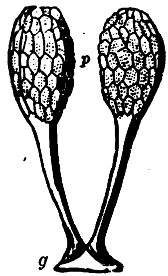


Fig. 186.

different cases. In the common nettle, and in the pellitory of the wall, the stamens have elastic filaments, which are at first bent down, so as to be covered by the calyx; but when the pollen is ripe, the filaments jerk out (fig. 155, p. 113), and scatter the powder on the pistils, which, in the nettle, occupy separate flowers. In the common barberry (fig. 187), the lower part of the filament is very irritable; and whenever it is touched, the stamen moves forward to the pistil. In the stylewort (*Stylidium*), as seen in fig. 188, the stamens and pistil are united in a common column

Fig. 185.—Spikelet of Wheat consisting of two bracts (empty glumes), *a a*, enclosing several flowers, *b b*; stamens, *s*, have long slender filaments which are attached to a part of the anther. The latter are very movable or versatile.

Fig. 186.—Pollinia, or pollen-masses, separated from the point above the stigma, with viscid matter attaching them at the base, *g*. The pollen-masses, *p*, are supported on stalks. These masses are *easily* detached by the agency of insects.

which projects from the flower; this column is very

Fig. 187.

Fig. 188.

Fig. 189.

Fig. 187.—Flower of the barberry (*Berberis vulgaris*), the stamens of which are irritable, and move towards the pistil when touched at their base. The irritability resembles that of the Sensitive-plant, and is ascribed to turgescence in certain cells, and contraction in others.

Fig. 188.—Stylewort of Australia (*Stylidium*), with two of the flowers, *a*, *b*, separated, showing the irritable column composed of stamens and pistil united. This column, when the pollen is ripe, jerks from one side of the flower to another, and thus scatters the powder.

Fig. 189.—Hazel (*Corylus Avellana*), showing two kinds of flowers which are produced before the leaves. ♂ The catkins bearing stamens. ♀ The pistil-bearing flowers which produce nuts. The plant is termed monœcious.

irritable at the angle where it leaves the flower, and, when touched, it passes with a sudden jerk from one side to the other, and thus scatters the pollen. In the hazel, where the pollen is in one set of flowers (fig. 189 ♂), and the pistil in another (fig. 189 ♀), the leaves might interfere with the application of the

Fig. 190.

Fig. 191.

pollen, and therefore they are not produced until it has been scattered. In the case of firs, which have their flowers arranged as in the hazel, stamens at one place and fruit-bearing cones at another, the evergreen leaves are very narrow, and the quantity of pollen produced is very great, so as to insure its reaching the

Fig. 190.—Willow, with a catkin or cluster of stamen-bearing flowers.

Fig. 191.—Willow, with a cluster of pistil-bearing flowers. The Willow is diœcious.

young cones. In America and also in Scotland, the pollen from pine-forests is sometimes carried to a great distance by winds, and falls in showers like sulphur. In the month of May, in this country, a visit to a forest of firs will show the large quantity of yellow powder which falls from the trees when shaken. In the case of cucumbers in a glass frame, where the wind cannot reach the flowers, the gardener takes the pollen from the one kind of flower and applies it to the other, in order that he may get fruit. In willows, the stamen-bearing and pistil-bearing flowers are on separate trees. In fig. 190 is seen a collection or catkin of flowers with stamens only; in fig. 191, another collection with pistils only. The two kinds of trees grow near each other, and the wind and insects carry the powder from the one to the other. In *Vallisneria spiralis* (fig. 15, p. 9), an aquatic plant, which grows in ditches in the south of Europe, the stamen-bearing plant (fig. 15 *a*) at a certain period is detached from the mud and rises to the surface of the water, where it floats and ripens its pollen. Soon after, the pistil-bearing plant (fig. 15 *b*), which still remains growing in the mud, sends up a long spiral stalk, as seen in the figure; this bears the flower to the surface, where it expands. The pollen is then wafted to it by the wind; thus the seed is perfected, and finally deposited in the mud.

Insects are often, in the arrangements of Providence, made the means of securing the production of seed. How often do we see the bees collecting the yellow powder of plants, and, while providing for the food of their young, aiding in dispersing the pollen! The

honey-like matter secreted by flowers renders them attractive to insects. It is produced by an alteration in the starch, which occupies cells at the bottom of the flowers. In the common crown-imperial of the gardens there is a distinct depression at the base of each petal,

Fig. 192.

Fig 193.

in which the honey or nectar is secreted. In common buttercups, a small scale at the bottom of each of the yellow petals points out the seat of the sugar-like matter. The peculiar insect-like forms of the flowers of

Fig. 192.—Flower of an Orchid, consisting of three outer divisions of the perianth, *s s s*, three inner, *p p l*, the latter *l* being the labellum, which is placed below by the twisting of the ovary; *e*, the spur of the labellum; *o*, the twisted ovary; *st*, the stigma; *a*, the anther containing masses of pollen.

Fig. 193.—Flower of Birthwort (*Aristolochia Clematitis*) showing the long tube and the expanding upper part of the flower. The seed-vessel, *o*, containing seed, is below the flower. The tube is lined with hairs which point downwards. An insect entering the flower easily passes the hairs, but in attempting to come out it is *stopped*.

orchids (fig. 192), such as the bee-orchis, the fly-orchis, the spider-orchis, and the butterfly-oncidium, seem to be connected with the attraction of insects to the flowers, in order to apply the pollen which in these plants is singular, both as regards its situation and nature. The little masses of pollen in the orchids adhere to the proboscis of the insect; thus, as the insect travels from flower to flower, the pollen is applied to the stigma. In the birthwort (*Aristolochia*), the flower consists of a long tube (fig. 193), at the lower part of which the stamens and pistil are situated. This position of the stamens and pistil is seen in fig. 184, p. 135, where the floral envelope is removed. This plant is frequented in its native country by an insect which enters the tube easily and gets into the little chamber. The stigma is matured before the pollen is ripe. On attempting to get out, the insect is prevented by a series of hairs in the tube, which all point downwards. It therefore moves about in the cavity, and when the pollen is ripe the flower withers and the insect escapes, carrying the pollen to the stigma of another flower. Such flowers are called *Dichogamous*, as the stamens and pistil ripen at different times.

QUESTIONS.

1. Which whorl of the flower is formed by the stamens?
2. What relation do the stamens bear to the floral envelopes as regards their position?
3. In double flowers, what change do the stamens undergo?
4. What are the parts of a stamen?
5. What is meant by a sessile anther?

6. How many coverings has the anther?
7. What is pollen, and where is it found?
8. What is meant by didynamous stamens?
9. What is meant by tetradynamous stamens?
10. When are the stamens said to be hypogynous?
11. When are the stamens said to be perigynous?
12. When are the stamens said to be epigynous?
13. Describe monadelphous stamens, and give an example.
14. Describe diadelphous stamens, and give an example.
15. Describe polyadelphous stamens, and give an example.
16. Describe syngenesious stamens, and mention some plants in which they occur.
17. Describe gynandrous stamens, and give an example.
18. Describe the filaments in the stamens of grasses.
19. Describe pollen-masses, and mention some plants in which they occur.
20. What is the use of the pollen?
21. How is it scattered?
22. What kind of stamens are found in the nettle?
23. What kind of stamens occur in the barberry?
24. Mention a special provision made for the application of the pollen to the pistil in the hazel.
25. What is the origin of the so-called sulphur-showers?
26. What is meant by a monœcious plant?
27. What is meant by a diœcious plant?
28. What agents are employed in scattering pollen?
29. What is meant by a dichogamous plant? Give an example, and describe the mode of fertilisation.

The Pistil.—This is the central part of the flower (fig. 1, *frontispiece*), and is composed of one or more leaves called carpels (figs. 194, 195). It may consist of a single carpel, as in the pea and vetch (fig. 213, p. 153); or of several, either distinct from each other, as in the

pæony and stonecrop (fig. 198, p. 144), or combined, as in the tulip and lily (fig. 199, p. 144). In the double-flowering cherry, in which the stamens are changed into petals, the pistil appears in the form of a flat leaf, as represented in fig. 194, or of a folded leaf, as in fig. 195. The plant does not produce fruit, on

Fig. 194.

Fig. 195.

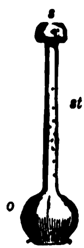


Fig. 196.

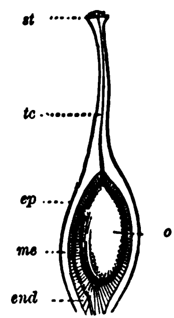


Fig. 197.

account of the change which has taken place in the stamens and pistil. The parts of the pistil are seen in fig. 196. The rounded top, *s*, is the stigma, the stalk below, *st*, is the style, and the lower swollen portion, *o*, is the ovary, containing the cellular ovules which become seeds. These parts are better seen in fig. 197, which represents the pistil of the apricot-tree laid open longitudinally, *st* being the stigma, *tc* the style, with a canal through it, *ep*, *me*, and *end*, the three coverings of

Figs. 194 and 195.—The pistil of the double-flowering cherry, composed of a leaf (*carpel*) either flat, as in 194, or folded, as in 195.

Fig. 196.—Pistil of Primrose (*Primula*), showing the ovary, *o*, below, the stigma, *s*, at the top, and the style, *st*, between them.

Fig. 197.—Pistil of Apricot-tree cut vertically. *ep*, Outer coat of ovary, *me*, middle coat, *end*, inner coat, which becomes the stone, *ov*, young seed or kernel, *tc*, style and its canal, *st*, stigma.

the ovary, and *ov* the young seed. When there is no style the stigma is sessile.

The carpels or leaves forming the pistil are sometimes separate, as in the common stonecrop (fig. 198), at other times they are united together, as in the primrose (fig. 196), so as to appear one. The number of carpels forming such a compound pistil can usually be ascertained by cutting across the ovary, as


Fig. 198.


Fig. 199.

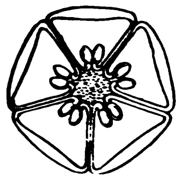


Fig. 200.

in fig. 199, where it is seen that there are three cavities containing seeds, and consequently three carpels. The ovules or young seeds are generally attached to

Fig. 198.—Pistil of Stonecrop (*Sedum*). It consists of five carpels, which are separate and distinct. Each carpel has its own ovary, style, and stigma. The pistil is apocarpous—*i.e.* is composed of separated carpels. At the base of the carpels are seen scales, which are called the nectary. Below the pistil is the part of the receptacle to which the other whorls were attached.

Fig. 199.—Ovary or lower part of the pistil of the Lily (*Lilium*) cut transversely. There are three loculaments, or cavities containing seeds, indicating the union of three carpels, and the ovary is said to be syncarpous and trilocular. The divisions in the ovary, called septa or dissepiments, are formed by the sides of the carpellary leaves. Each septum is double, and the number of septa corresponds with the number of the carpels. The ovules are placed collaterally, in pairs, in each loculament, and are attached to a central point called placenta.

Fig. 200.—Pistil formed of five carpels. Section of ovary showing five partitions and five cavities, with ovules attached to a central placenta.

the edge of the carpels; but sometimes they are united to the axis, as in the primrose, without any apparent attachment to the carpels. In certain cases, as in cycads and conifers, the ovules are not covered by carpels, and are called naked, because the pollen is at once applied to them without the intervention of a

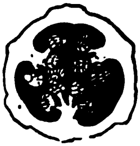


Fig. 201.

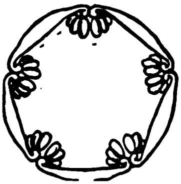


Fig. 202.

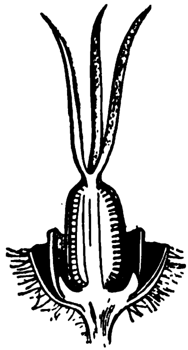


Fig. 203.

stigma. The number of styles in a flower was used by Linnæus as a mode of distinguishing certain divisions in his system called orders; the Greek numerals being prefixed to the term *gynia*, meaning pistil. (See p. 211.)

Divisions are formed in ovaries by the folded edges of the contiguous carpels uniting with each other, and at the same time attached to the central axis where the placentas and ovules are situated. In fig. 199 there

Fig. 201.—Ovary of an Orchid cut transversely, showing three parietal placentas bearing ovules.

Fig. 202.—Section of ovary formed by five carpels, with the ovules attached to the points where the carpels meet each other. The placentas are five and parietal.

Fig. 203.—Pistil of Rose-campion cut vertically, showing a free placenta in the axis bearing numerous ovules.

are three carpels, the edges of which meet together, and thus three partitions are produced, and three cavities containing ovules. In fig. 200 there are five carpels united. Sometimes the partitions do not extend to

Fig. 205.

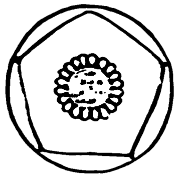


Fig. 204.

Fig. 206.

the centre, and then there is only one cavity in the ovary, although there may be several carpels, as in the poppy, and the mignonette and orchis (fig. 201). In fig. 202, the ovules appear on the walls of the ovary.

Fig. 204.—Ovary formed of five carpels, and the ovules attached to a free placenta in the centre. There are no partitions.

Fig. 205.—Pistil of Wallflower, consisting of two carpels, between which is a spurious partition, *cl*, formed by the placentas, *cn*; ovules, *ov*, style, *s*.

Fig. 206.—Pistil of the Lady's-mantle (*Alchemilla*), with the style, *s*, arising from the apparent base of the ovary.

Occasionally no partitions whatever are seen, and the ovules are attached to the central axis directly, as in the red campion (fig. 203), and in the primrose (fig. 204). Spurious partitions are formed in ovaries by the folding in of the back or front of the carpels, as in some papilionaceous flowers and in flax, or by a prolongation of the placentas, as in wallflower (fig. 205, *cl*). Carpels are sometimes united together completely, at other times the ovaries only are combined, while the style and stigma are separate (fig. 203), or the ovaries and styles are united to each other and the stigmas are free, or the styles are united while the ovaries are free, as in the dead-nettle and comfrey. The number of carpels forming a pistil may be determined by the number of styles, or by the divisions seen on cutting across the ovary. The style is usually at the apex of the ovary, but sometimes it arises below the apparent apex, as in lady's-mantle (fig. 206). The stigma is a viscid spot at the upper end of the style, or, if there is no style, on the top of the ovary, formed of loose cells, to which the pollen is applied after the bursting of the anthers. The stigma may either be simple (fig. 196, *s*) or divided (fig. 183, *s*, p. 135).

Ovule.—The ovule is the young seed contained in the ovary. There may be one or more ovules. Each ovule is covered by at least two coats, which inclose a central part in which the young plant is formed. At one part of the ovule there is a small opening. In fig. 207 an ovule is represented with its two coverings, inside which is the central nucleus, *n*, the sac, *s*, containing a minute cell, *c*, in which the embryo, *e*, is seen

near the opening at the top. The nourishing vessels enter the ovule at *ch*. Sometimes the ovule, in place of being straight, is turned round, as in fig. 208, where the opening, *f*, is represented as pointing downwards.

Functions of the Stamens and Pistil.—These are called essential organs of the flower, inasmuch as they are required for producing perfect seed containing in its interior the young (embryo) plant. Hence a flower having stamens and pistil is called perfect. A flower having stamens only is staminate; one having pistil only is pistillate. When the stamens are in one flower, and the pistil in another flower on the same plant, it is called monœcious; when the staminate and pistillate flowers are on different plants, the term diœcious is applied. These occurrences are marked by the following symbols:—

☿ Perfect flower, having both stamens and pistil.

♂ Staminiferous, staminate, or sterile flower.

♀ Pistilliferous, pistillate, or fertile flower.

♂ ♀ Having separate staminate and pistillate flowers.

♂—♀ Monœcious species, having staminate and pistillate flowers on the same plant.

♂ : ♀ Diœcious species, having staminate and pistillate flowers on different plants.

The pollen is contained in the anther, from which it is discharged in the modes already mentioned (page 131).

The grains of pollen, when discharged from the anther, are applied to the stigma (fig. 209, *st*), and after lying on it for a certain length of time, they send out tube-like prolongations, as shown in fig. 209, where two pollen-grains are seen lying on the top of the stigma,

which is split open, along with part of the style, to show the pollen-tubes. In fig. 210 there is a magnified representation of a pollen-grain giving out three tubes,

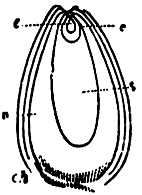


Fig. 207.

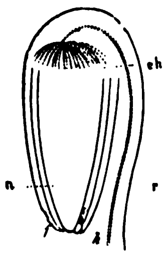


Fig. 208.

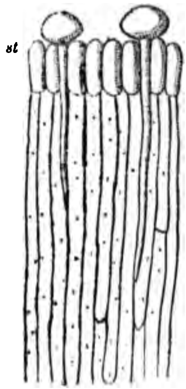


Fig. 209.

one of which, *t*, is considerably elongated. These tubes reach the ovule in the ovary (fig. 211, *ve*), and by this

Fig. 207.—Orthotropous or straight ovule of Polygonum, showing the coats of the ovule on the outside of the nucleus, *n*, the embryo-sac, *s*, containing a vesicle, *c*, in which the rudimentary embryo, *e*, is seen close to the foramen or micropyle. The chalaza is marked *ch*.

Fig. 208.—Anatropous or inverted ovule of Dandelion (*Leontodon Taraxacum*), showing the coats of the ovule surrounding the nucleus, *n*, which is inverted, so that its base, *ch*, where the chalaza exists, is removed from the base or hilum of the ovule, *h*, while the foramen, *f*, is near the base. The connection between the base of the ovule and the base of the nucleus at *ch* is kept up by means of the raphe or cord, *r*.

Fig. 209.—The style and stigma laid open. Two grains of pollen on the top of the stigma, protruding tubes which descend through the stigma and style to the ovules.

means the embryo plant is formed (fig. 212, *e*). After this process has taken place, the pistil undergoes marked

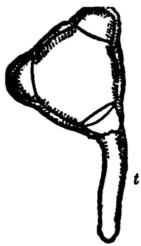


Fig. 210.

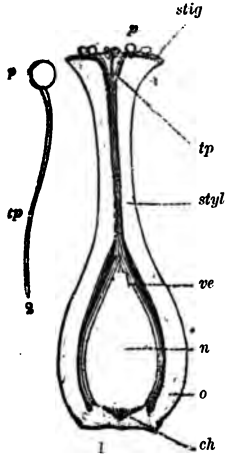


Fig. 211.

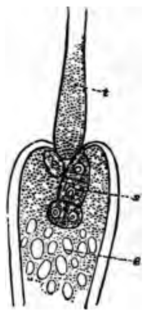


Fig. 212.

changes, by which it becomes the fruit containing the seed, in the interior of which is the young germ.

Fig. 210.—Pollen grain, much magnified, showing three points where tubes come out. One of the tubes, *t*, is considerably elongated.

Fig. 211.—Pistil and pollen of Polygonum. 1. Stigma, *stig*, with pollen-grains, *p*, adherent to it, sending tubes, *tp*, down the conducting tissue of the style, *styl*; the ovary, *o*, containing the ovule with its covering and central cellular mass or nucleus, *n*, enclosing a rudimentary embryo-sac, *ve*, in which ultimately the embryo is developed. The base of the ovule which was attached to the placenta is marked *ch*. 2. Pollen-grain, *p*, separated; tube, *tp*.

Fig. 212.—Section of the ovule of Œnothera, showing the pollen-tube, *t*, with its enlarged extremity applied to the end of the embryo-sac, and introverting it slightly; the germinal vesicle in the sac has been fertilised, and has divided into two parts, the upper part forming a suspensor, *s*, and the lower dividing into four parts, which form a globular mass—the rudimentary embryo, surrounded by cells, *e*.

By taking the pollen of one species of plant and applying it to a different species, seeds are produced, which, when they sprout, give origin to what are called hybrids. This effect is probably referred to in Deut. xxii. 9, where it is said, "Thou shalt not sow thy vineyard with divers seeds, lest the fruit of thy seed which thou hast sown, and the fruit of thy vineyard, be defiled." Gardeners constantly attempt to produce hybrids, and thus to improve the quality of flowers or fruit, and to get hardy varieties. By inoculating different species of rhododendron, gardeners have secured the fine colour of the Nepal rhododendron with the hardiness of the American species. A vast number of florist's flowers, as varieties of pelargonium, fuchsia, and calceolaria, are hybrids.

QUESTIONS.

1. Where is the pistil situated?
2. Of what parts is it composed?
3. What is meant by a carpel?
4. What is the ovary, and what does it contain?
5. What is meant by a sessile stigma?
6. What is meant by an apocarpous pistil?
7. What is meant by a syncarpous pistil?
8. What is meant by naked ovules? Give an example.
9. How are divisions (septa) in ovaries formed?
10. What is meant by a placenta?
11. What is meant by a central placenta?
12. What is meant by a parietal placenta?
13. How are spurious divisions in ovaries formed?
14. Explain the different modes in which carpels are united together.
15. How can the number of carpels forming a pistil be ascertained?

16. What is the ovule?
17. How many coverings exist in the ovule?
18. Is there any opening in the ovule?
19. Describe the position of the micropyle in an erect and in an inverted ovule.
20. What are the functions of the stamens and pistil?
21. What is meant by a staminate, and what by a pistillate, flower?
22. Explain the symbols ☿, ♂, ♀.
23. Explain the symbols ♂—♀ and ♂ : ♀.
24. To what part of the pistil is the pollen applied?
25. Describe the changes which take place in the pollen after its application to the pistil.
26. What is meant by the germ-vesicle in the ovule?
27. What is meant by a hybrid plant?

The Fruit.—The term fruit, in botanical language, is applied to the mature perfect pistil, whether dry or succulent. When we examine fruits, however, we find them formed in various ways. Some, as the pea, bean, and vetch (fig. 213), consist solely of the pistil, slightly altered; others, as the grape, peach, and plum, consist of the pistil, changed so as to assume a succulent character, either entirely, as in the grape, or partially, as in stone-fruit; others, as the gooseberry, currant (fig. 214), apple, pear, pomegranate, are formed not only by the pistil, but also by the calyx, a portion of which is seen at the top of most of these fruits in the form of brownish scales. The hazel-fruit (fig. 215) consists of the pistil developed into the nut, with a covering of bracts, called the husk, outside; and the fruit of the oak (the acorn) has a cup-like covering formed by bracts (fig. 216, *a*). In the strawberry (fig. 217) the *succulent part*, which is eaten, consists of the enlarged

growing point, bearing on its surface numerous small carpels or fruits, which are often called seeds. The grain of wheat, and other cereal grains, consist of seeds

Fig. 213.

Fig. 214.

incorporated with seed-vessels, and are in reality fruits, although they appear like seeds. What, then, is called bare grain in the Bible, is the bare fruit deprived of its husk-like coverings. The Greek word for grain, *Kokkos*, is different from that for seed, *Sperma*. The mulberry (fig.

Fig. 213.—Pod of Vetch, composed of the pistil, with style and stigma at the summit. The fruit in this case is composed of a single carpel containing numerous seeds.

Fig. 214.—Fruit of Currant, composed partly of the pistil and partly of the calyx; the withered remains of part of the calyx are seen at the summit of each currant.

218), as well as the pine-apple (fig. 219), the bread-fruit,

Fig. 215.

Fig. 216.

the cone (fig. 220), and the fig (fig. 133, p. 99), are made up of a congeries of pistils formed by separate flowers,

Fig. 217.

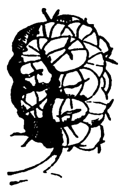


Fig. 218.

and all combined into one mass. In the first four, the flowers are on the outside of a common receptacle or

Fig. 215.—The fruit of the Hazel, consisting of the nut, with the husk outside. The husk is composed of floral leaves or bracts.

Fig. 216.—Fruit of the Oak (acorn), *b*, with its cup or outer covering of altered leaves or bracts, *a*.

Fig. 217.—Strawberry-fruit, consisting of a succulent receptacle, on which are scattered numerous fruits or achenes, resembling seeds.

Fig. 218.—Fruit of Mulberry, composed of the pistils of several flowers united into one succulent mass.

axis; while in the fig the succulent receptacle is curved upwards and inwards, so as to be hollow, and thus bears the flowers inside, as seen in fig. 133. In the fig, what are called seeds are in reality fruits, like those on the top of the strawberry, but produced by numerous flowers in place of one.

Fruits are divided into those which open in order to scatter the seeds, and those which do not open. Among

Fig. 219.

Fig. 220.

the former may be noticed—1. the follicle, a carpel opening on one side, as in the pæony (fig. 221), and the stone-crop (fig. 198, p. 144), where there are several follicles

Fig. 219.—Pine-apple, a fruit consisting of several succulent fruits formed by different flowers, and all united into one. The scales outside are modified leaves, while the crown is a series of leaves unaltered.

Fig. 220.—Cone of Fir, a fruit consisting of scales or hardened leaves, each representing a separate flower. The fruit is made up of numerous flowers united.

forming the fruit; 2. the legume, as in the pea (fig. 222) and bean, a carpel opening by both sides; 3. siliqua, a pod formed of the two united carpels opening along each edge in the form of two valves, as in wallflower (fig. 205, p. 146)—when short it is called silicula (fig. 223); 4. the capsule, a seed-vessel composed of several dry united carpels, which separate from each other in various ways, opening by teeth as in the campion (fig. 224), by valves as in the violet (fig. 225), by a lid as in henbane (fig. 226), pimpernel (fig. 227), and the monkey-pot (fig. 228), by pores below the stigma as in the poppy (fig. 229).

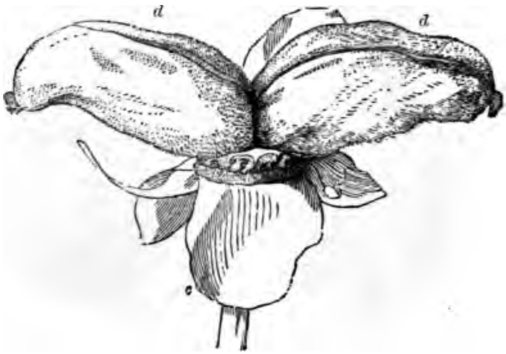


Fig. 221.

Among fruits which do not open may be noticed—1. the achene (fig. 206, p. 146)—a dry single-seeded fruit, such as that of each floret of the dandelion and sunflower (figs. 130 and 162, pp. 98 and 120),—in the ranunculus and strawberry (fig. 217, p. 154) there are

Fig. 221.—Fruit of Pæony, consisting of two carpels, *d d*, opening on their inner side, and called follicles. Calyx, *c*, below the fruit.

numerous achenes, and in the dead-nettle and comfrey

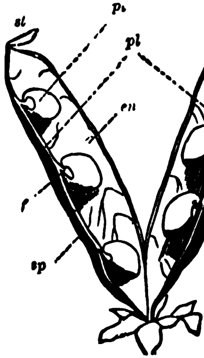


Fig. 222.

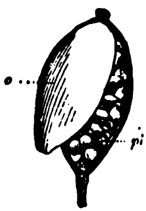


Fig. 223. Fig. 224. Fig. 225.

four ; 2. the nut, a single-seeded dry fruit, as in the hazel

Fig. 222.—Legume of Pea opening on both sides. It is formed by one carpel, and the seeds are attached along one side, *pl*. Outer coat of seed-vessel, *sp* ; inner coat, *en*. Placenta, *pl*. Stalk of seed, *f*. Style and stigma, *st*.

Fig. 223.—Silicula of Whitlow-grass (*Draba*), opening by two flat valves, *o*, from below upwards, having parietal placentas, *pl*, united by a membrane or replum. The seeds are attached to the placentas on either side of the seed-vessel.

Fig. 224.—Seed-vessel or capsule of Campion (*Lychnis*), opening by ten teeth at the apex. The calyx is seen surrounding the seed-vessel, but not adherent.

Fig. 225.—The capsule of the Pansy (*Viola tricolor*), opening by three valves through the back of the carpels. The placentas and seeds are placed on the middle of the valves.

(fig. 215, p. 154) and oak (fig. 216, p. 154), with a hard shell outside covered by bracts; 3. the drupe, a succulent fruit, such as the cherry and peach, called stone-fruits, with three coverings—the skin, the fleshy part, and the stone containing the seed or kernel inside; 4. the berry, where the seeds are enclosed in pulpy matter within a covering formed either by the wall of the mature ovary alone, as in grape and potato-apple, or by the wall of the ovary in combination with the calyx, as in the gooseberry and currant (fig. 214, p. 153); 5. the apple, where there are usually five cavities in the centre con-


Fig. 226.


Fig. 227.

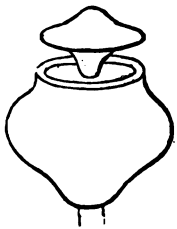


Fig. 228.

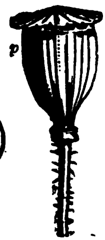


Fig. 229.

taining seeds, and the outer part consists of fleshy cells covered by a skin formed partly by the calyx, as in the apple and pear.

In common language we apply the name fruit chiefly to that which is succulent and eatable.

Fig. 226.—Seed-vessel of Henbane (*Hyoscyamus niger*), opening by a lid; the capsule has been called Pyxis (a box).

Fig. 227.—Seed-vessel of the Scarlet Pimpernel (*Anagallis arvensis*), opening by transverse dehiscence—that is, by a lid.

Fig. 228.—Fruit of the Monkey-pot (*Lecythis ollaria*), opening by a lid. The seeds are the Sapucaya nuts of the shops. They resemble the Brazil nuts, and are relished by monkeys, which are often entrapped when taking the nuts from the interior of the capsule.

Fig. 229.—Capsule of Poppy (*Papaver*), opening by pores, *p*, under the broad stigma.

Grafting.—Various means are adopted by gardeners to render edible fruits more fit for the dessert. All the varieties of apple, for instance, are produced from the

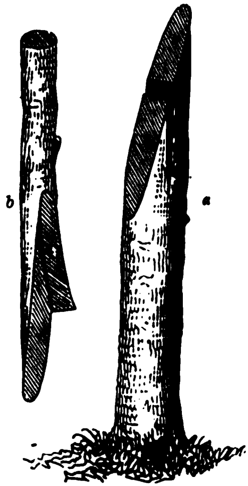


Fig. 230.

wild crab by the art of horticulture. The mode in which this has been accomplished is by the process of grafting, or by taking a slip from one tree and making it adhere to the stem of another tree growing in the soil (fig. 230). Grafting is of two kinds. In one case a slip or graft is taken from a wild tree, bearing comparatively worthless fruit, such as the sour crab-apple, and is attached to a good stock or stem which has been fully matured, and which shows great vigour. Another

Fig. 230.—Whip or tongue grafting. The stock, *a*, is cut in such a way as to have a tongue-like process, into which the slip or scion, *b*, similarly cut, is inserted.

kind of grafting is accomplished by taking a slip from a tree bearing good fruit, and uniting it with the stock of a wild plant. In both instances good is effected. In the first case, the sap of the excellent stock circulates through the slip or graft, and imparts vigour to it, so as to enable it to produce good fruit. The better the stock on which the graft is placed, and the more nourishing its sap, the more likely is the fruit of the grafted plant to be good. In the second kind of grafting—viz. the insertion of a slip from a good fruit-tree on a crab or wild stock—there is a combination between the two also in such a way as to cause often early flowering and early ripening of the fruit; and thus a useful fruit-bearing tree is produced.

Grafting is adopted in the case of many fruits, such as apples, pears, grapes, peaches, and plums. By grafting there is for a time an arrestment in the growth of the slip; and it is not until it is fully united to the stock that it grows and produces fruit. If we sow the seed of any apple, however fine, in ordinary soil, and allow it to grow wild, it will revert to the original species, and will produce unpalatable crab-apples. Such is also the case with slips put into the soil. It is only by careful cultivation and grafting that the good varieties are kept up.

The flavour of our table-fruits depends on the presence of certain chemical ingredients. If these are not developed, then the fruit wants some of its characteristics. Even after trees have been grafted, they are apt to run to leaves, in place of flowering and fruiting. In such cases pruning must be adopted, in order to prevent

them from becoming rampant. By inflicting an injury on the tree—as cutting a ring out of the bark, or by checking its roots—gardeners often make barren fruit-trees become productive.

The fruit, when ripe, is usually detached from the tree; but sometimes the fruit of one year remains until that of another is produced. Thus in the orange-tree we meet with ripe fruit, green fruit, and flowers at the same time. At times the fruit appears to be complete, and yet it contains no seeds. Thus seedless grapes and seedless oranges are often met with. In such cases, although the fruit has a fair appearance, it cannot be said to be perfect, for it has not fulfilled the object of its production—namely, the propagation of the plant. High cultivation may have a tendency to induce this state, and it may perhaps depend occasionally on the age of the trees. Bullar states that the thinness of the rind of the St. Michael orange, and its freedom from pips, is owing to the latter cause—the trees, when young, producing fruit with thick rinds and plenty of seeds.

QUESTIONS.

1. What is meant by the term fruit in botanical language?
2. Give an instance of a fruit formed by one carpel.
3. Give an instance of a fruit formed by several separate carpels.
4. Give an instance of a fruit formed by several carpels cohering together.
5. Describe the parts which form the fruit of a peach.
6. Describe the parts which form the fruit of a gooseberry, and explain in what respect it differs from a grape.
7. Describe the fruit of the hazel.

8. Describe the fruit of the oak.
9. What is the nature of a grain of wheat.
10. Describe the fruit of a strawberry, and explain how it differs from the raspberry.
11. What kind of fruit is the pine-apple?
12. Describe the fruit of the Scotch fir.
13. Describe a mulberry, and point out the difference between it and a bramble.
14. Describe the fruit of the fig-tree.
15. What is essential for a perfect fruit?
16. How is the seed scattered?
17. How do some fruits open to scatter the seed?
18. Describe a follicle, and explain how it differs from a legume. Give examples.
19. Describe a siliqua and silicula. Give examples.
20. Describe a capsule. Give an example.
21. Describe the mode of opening in the fruit of the henbane, the rose-campion, the violet, and the poppy.
22. What is an achene? Give an example.
23. Describe a nut. Give an example.
24. Describe a drupe. Give an example.
25. In what respect does the pulp of the berry differ from the flesh of the peach?
26. Describe the parts of an apple.
27. What is meant by grafting, and how is it effected?
28. Mention two kinds of grafting.
29. How does grafting act on the fruit?
30. What is the origin of the apple?
31. Do fruits in every instance produce seeds?
32. How is the production of edible fruits hastened?

The Seed.—The seed is usually contained in the seed-vessel (angiospermous plants), or, in other words, in the fruit (fig. 222, p. 157). In some cases the seed is naked, that is, not contained in a seed-vessel (gymnospermous plants, such as the fir). In order that it may be complete, it must contain the rudiment of the

young plant, or what is called the embryo. On removing the skin of the seed, it is sometimes found that the embryo occupies the whole of the interior. This is the case in the bean, pea (fig. 222, p. 157), and lupin, the fleshy cotyledons of which form the great bulk of the seed ; so also in the common stock (fig. 231), and other plants of the cabbage order. At other times the embryo forms only a part of the seed, as in palms (fig. 232) and lychnis (fig. 233). In these instances there is a separate store of nourishing

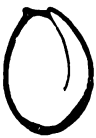


Fig. 231.

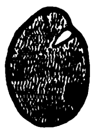


Fig. 232.


Fig. 233.

matter called albumen (perisperm), which, after the seed has been sown, is gradually dissolved, so as to be taken up by the plant in the early stages of growth. The first-mentioned seeds are called exalbuminous (aperispermic), the latter albuminous (perispermic).

The mode in which seeds are scattered is deserving of notice. In some cases, as in the gooseberry, grape, apple, and coco-nut, the fruit falls without opening, and

Fig. 231.—Seed of Common Stock Gillyflower, cut open in a vertical manner, showing the embryo plant, of a white colour, occupying the whole of the interior. The coverings of the seed are dark, and a black line indicates the folding of the young root on the cotyledons.

Fig. 232.—Seed of a Palm, cut vertically, showing the minute white embryo occupying only a small part of it. The bulk of this seed is made up by a separate store of nourishing matter.

Fig. 233.—Seed of Red Campion (*Lychnis*), cut vertically, showing the embryo curved round the store of nourishment, which is in the centre.

gradually decays, forming a sort of manure with the soil in which the plant sprouts. In other cases, the seed-vessels open and scatter the seeds. In the common broom, the pod, when ripe, opens with considerable force; so also the fruit of the sandbox-tree, and the balsam, which is called Touch-me-not, on account of its seed-vessel bursting when touched (figs. 234, 235). The squirting cucumber, when handled in its ripe state, gives way at the point where the fruit joins the stalk,

Fig. 234.

Fig. 235.

and the seeds are sent out with amazing force. The common geranium seed-vessels curl up when ripe, as seen in fig. 236, and scatter the seeds. In the case of firs (fig. 237), bignonias, and some other plants, the seeds aref urnished with winged appendages; while in the cotton-plant and asclepias (fig. 238), they have hairs attached to them, by means of which they are wafted to a distance. The action of moisture in open-

Fig. 234.—Ripe fruit of balsam (*Impatiens noli-me-tangere*), in its unopened condition.

Fig. 235.—Fruit of the same plant opening by five recurved valves.

ing seed-vessels is seen in a succulent species of fig-

Fig. 236.

Fig. 237.

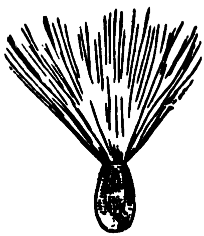


Fig. 238.

Fig. 239.

Fig. 240.

marigold (figs. 239 and 240), from the Cape of Good Hope, and in the rose of Jericho.

Fig. 236.—Fruit of Geranium, showing the different parts of which it is composed curling upwards, so as to scatter the seed.

Fig. 237.—Naked winged seed of Common Fir.

Fig. 238.—Seed of Asclepias, with a cluster of hairs arising from the edges of the opening in the seed.

Fig. 239.—Seed-vessel of a species of Fig-Marigold (*Mesembryanthemum Tripolium*) in a closed state.

Fig. 240.—The same seed-vessel, with its valves expanded, after having been moistened with water.

In composite plants, such as the dandelion (fig. 130, p. 98), thistle (fig. 143, p. 104), and artichoke, what is commonly called the seed is in reality the fruit with the calyx attached in the form of hairs. The down of the thistle consists of calycine hairs. Each fruit contains a single seed, and it is interesting to know the process by which this single-seeded fruit is deposited in the soil. In these plants there are numerous flowers on a common receptacle, which is at first succulent and nutritive. In the young state this receptacle contains much starch, which is gradually changed into sugar, so as to be easily taken up in the form of a saccharine solution by the flower. In the artichoke, it is then fit to be used for food. As the flower grows, and the fruit is perfected, the receptacle loses its sugary matter and becomes dry. In this state it is unfit for food. Meanwhile the hairy calyx attached to the fruit increases so as to be ready to waft it to a distance. In the dandelion, the leaves which surround the clusters or heads of flowers (fig. 130, p. 98) are turned downwards, the receptacle becomes convex and dry, the hairs spread out so as to form a parachute-like appendage to each fruit, and collectively to present the appearance of a ball. In this way the fruit is prepared for being dispersed by the winds.

The number of seeds produced by plants is often very great. Thus a single Seje palm produces 8000, a common spear-thistle 24,000, an Oriental poppy 32,000, and a tobacco-plant 40,000 or more.

The Embryo.—The young plant or embryo is contained in the perfect seed. It consists of three parts—

the young root (radicle), the seed-leaves or seed-lobes (cotyledons), and the young stem (plumule). These parts are easily seen in the common pea after removing the skin, as shown in fig. 20, p. 13, where *r* is the radicle, *c c* the cotyledons, and *g* the plumule.

In flowering plants there are two kinds of embryos; one in which there is only a single cotyledon, the plant being called monocotyledonous, and the other in which there are two, the plant being called dicotyledonous. In flowerless plants there are no cotyledons, and they are called acotyledonous. The embryo consists at first en-

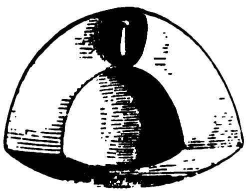


Fig. 241.

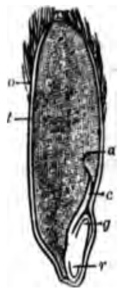


Fig. 242.

tirely of cells. In the case of flowering plants it is con tained in the seed, and along with it there is a store of nourishment for its future growth. This nutritive matter is in some cases incorporated with the young plant, as in the pea, the large fleshy lobes of which are part of

Fig. 241.—Section of part of the Coco-nut seed, showing the young plant in a cavity at one end, quite separate from the nourishing matter around.

Fig. 242.—Grain of Oats (*Avena sativa*). *o t*, Its coverings; *c g r*, young plant; *c*, being its seed-leaf; *g*, the young bud of the stem; and *r*, part of the axis whence the root proceeds; *a*, store of nourishment, called albumen.

the young plant (fig. 20, p. 13); in other cases it is separate from the young plant, as in the coco-nut and wheat. In fig. 241 there is a representation of part of the eatable portion of the coco-nut, with the small embryo plant lying in a cavity at the top. This cavity is in the flesh of the nut, immediately below the hole in the hard shell. The little plant weighs only a few grains, while the nourishing matter weighs many ounces. In palms generally the young plant occupies a small part of the seed, and the nourishment is abundant, and sometimes, as in the date and the ivory-palm, very hard. In the grains of wheat, barley, and oats, the young plant is minute, while the starch and glutinous matter stored up along with it is large. Fig. 242 represents a grain of oats, *o t* being its covering, *c g r* the young plant, with its root, stem, and leaves, and *a* the mass of nourishment laid up for the use of the young plant, and not incorporated with it.

QUESTIONS.

1. What organ contains the seed?
2. What is meant by naked seeds?
3. What is the essential part of a seed?
4. What is meant by an exalbuminous or aperispermic seed? Give an example.
5. What is meant by an albuminous or perispermic seed. Give an example.
6. How are seeds scattered?
7. How does the seed-vessel of the squirting-cucumber scatter the seeds?
8. How are geranium-seeds scattered?
9. What kind of seeds are seen in the common fir?
10. What is the use of hairs attached to seeds? Give *an example.*

11. Describe the nature of the fruit and seed in the dandelion.

12. What is the thistle-down ?

13. Describe the mode in which the fruit of the dandelion is scattered.

14. What is the part of the artichoke which bears the fruit ?

15. What is the organ called the embryo ?

16. What are the parts of the embryo in flowering plants ?

17. Describe the embryo of the common pea.

18. Mention two kinds of embryos in flowering plants. Give an example of each.

19. What kind of embryo is found in acotyledonous plants ?

20. Describe the position and the appearance of the embryo of the coco-nut.

21. What kind of albumen surrounds the embryo in the ivory-palm seed ?

22. In what part of the grain of oats does the embryo plant lie ?

23. What kind of embryo exists in the red campion ?

Sprouting of the seed, or Germination.—Seeds when ripe fall from the plant into the soil, or they are transported in various ways by means of winds and streams, or by the agency of man and animals, and are deposited in situations fitted for their growth. When the seed is placed in favourable circumstances, the little plant begins to sprout or germinate. In order that this process may take place, it is necessary that moisture, heat, and air should be present, and it is also important that the plant at first should be excluded from direct light. The supply of these requisites must be properly regulated, and in doing so the nature of the soil must be attended to. One of the most important

operations for enabling grain to grow and give abundant produce is draining. Undrained soil, from having much moisture, is cold, is deficient in the supply of air, and prevents the constant renewal of food to the roots. Draining carries away superabundant moisture, allows a constant supply of fresh fluid nourishment to penetrate through the soil at the roots, permits the access of air and heat, and thus materially contributes to the health and vigour of the crops. The soil must therefore be prepared and fitted for the seed, otherwise, as far as regards useful and nutritious plants, the sowing will be unproductive.

When seeds are sown naturally, they have only a slight covering of soil, and if they happen to become deeply buried, the proper access of air is prevented, and their sprouting is retarded. In sowing seeds, we should imitate what occurs in nature. They should be placed at a moderate and equal depth. Hence the necessity for regular ploughing, in order that all the grains may be at a proper distance from the surface of the soil, and that the growth and progress of the plants may be uniform. When ploughing is irregular, the grains sink to different depths, some plants come up before others, and they ripen at different periods—an occurrence which tends to injure the harvest; for the ripe grain, when allowed to remain beyond a certain period, loses part of its nutritious qualities, and thus the produce of the field is diminished in value. Seeds often lie long dormant, especially when placed too deep in the earth, and it is only when the soil is turned up and air admitted that they spring up. Many are the instances of

seeds retaining vitality long, when buried in the ground under certain conditions. The seeds of white clover may remain in the soil for many years, and yet, when brought near the surface, so as to be within the action of the air, germinate freely. While seeds naturally preserved in the soil and in peat-mosses retain their vitality, it is not easy for man to imitate these conditions. The statements as to the germination of mummy-wheat require confirmation. No doubt there are numerous fields of what is called mummy-wheat in Britain, but none can be proved by unimpeachable evidence to be the produce of grains of the same age as the mummies.

The various phenomena connected with the sprouting of the seed are well seen in the malting of barley. The grain is exposed to moisture, heat, air, and is kept in comparative darkness. It is placed in circumstances fitted for its sprouting. A marked change takes place in the contents of the grain. The starch, which is insoluble in water, and unfit for the nourishment of the plant, is converted into sugar, which is soluble, and easily taken up by the cells of the plant as food. During this process heat is developed. The young roots are first protruded, and then the stem rises, surrounded by a leaf called a cotyledon, or seed-leaf. If the barley were allowed to grow, the whole of the sugar would be used by the plant. But man wishes to get the sugar, and he therefore stops the growth of the plant by drying it, and thus makes malt. The progress of growth in the oat is seen in fig. 243, which represents the embryo at one end of the grain, the curved dotted lines marking

the dimensions of the grain. The letter *r* indicates the young roots passing through sheaths, *co*, and covered

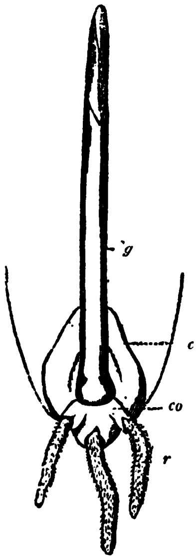


Fig. 243.

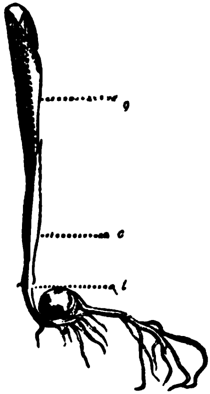


Fig. 244.

Fig. 245.

Fig. 246.

with little cellular hairs, ready to take up fluid nourishment; *c* is the cotyledon—*i.e.* the seed-lobe or seed-leaf;

Fig. 243.—Germination or sprouting of the grain of Oats. *r*, roots passing through sheaths, *co*; *c*, cotyledon; *g*, the first leaves of the plant. The plant is monocotyledonous, or has only one cotyledon.

Fig. 244.—Germination or sprouting of the grain of Maize or Indian corn. *t*, Stalk supporting the cotyledon, *c*; *g*, the first leaves of the plant. It is monocotyledonous.

Fig. 245.—Grain of Wheat, seen on its inner surface.

Fig. 246.—Grain of Wheat, seen on its outer surface, with the small embryo, *b*, at one side; all the rest of the grain being occupied with nourishing matter, *a*, called albumen, which dies and is *dissolved.*

g is the young stalk or stem rising upwards. In the Indian corn (fig. 244) the same parts are seen—the roots, *r*, the cotyledon, *c*, united to the grain by a stalk, *t*, and the young stem-leaves, *g*.

"Except a corn [grain] of wheat fall into the ground and die, it abideth alone; but if it die, it bringeth forth much fruit." We see an apt illustration here. The great bulk of the grain of wheat (fig. 245) is composed of nutritious matter (fig. 246 *a*), separate from the little plant or embryo (fig. 246 *b*). This matter must all be changed and dissolved, in order that the plant may spring. Unless it dies, and undergoes solution, there can be no nourishment conveyed. Again, the sprouting of the grain is taken by St. Paul as an emblem of the resurrection. The bare or naked grain which is sown is not quickened except it die; and out of the corruption and dissolution which it undergoes there springs up, by a wondrous metamorphosis, the blade of wheat, or of some other grain.

In many plants the embryo, in place of having only one cotyledon, as in grasses and palms, has two. These cotyledons, during the sprouting of the plant, either rise above ground, and appear as temporary leaves of a peculiar form, as is seen in the lupin; or they remain below ground as fleshy lobes, and are gradually absorbed, as in the bean and pea (fig. 20, p. 13). Fig. 247 represents the germination of the common haricot, where *r* is the root of the young plant, *t* is the stalk supporting the two cotyledons, *c c*, and *g g* are the first proper leaves of the plant. In the orange (fig. 248), the cotyledons, *c*, remain below ground in the seed, *s*;

such is also the case in the bean and pea, in which the cotyledons form the great bulk of the seed. In plants which have no flowers, as ferns, mosses, sea-weeds, and

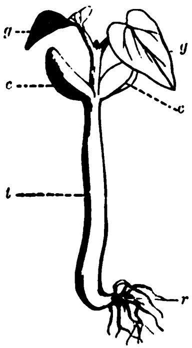


Fig. 247.

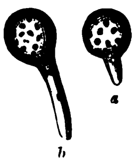


Fig. 249.

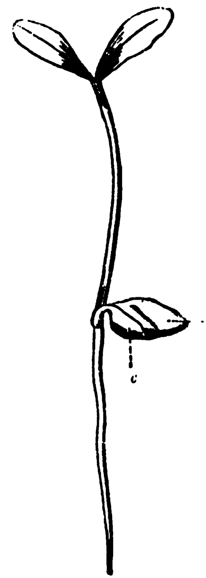


Fig. 248.

fungi, the little germs are simple cells without any cotyledon, which send out cellular roots from various

Fig. 247.—Germination or sprouting of the Haricot (*Phaseolus vulgaris*). *t*, Stalk supporting two cotyledons, *c c*; *g g*, the first leaves. The plant is dicotyledonous.

Fig. 248.—Germination or sprouting of the Orange. *c*, The two cotyledons enclosed in the seed, *t*, and remaining under ground. The plant is dicotyledonous.

Fig. 249.—Germinating spores or germs of a species of Liverwort (*Marchantia polymorpha*), in different stages of growth. A small cellular protuberance first appears, *a*, which ultimately elongates, as seen at *b*. The plant is acotyledonous.

parts of their surface. In fig. 249 there is a representation of the germs of a flowerless plant, consisting of single cells, with tapering projections forming the roots. There is here no distinction of parts, as in the embryo or germ of flowering plants.

It will thus be seen that, according to the nature of the embryo or young plant, the whole vegetable kingdom can be divided into—1. Flowering plants having one cotyledon, called monocotyledonous plants (figs. 243 and 244); 2. Flowering plants having two cotyledons, called dicotyledonous plants (figs. 247 and 248); 3. Flowerless plants without cotyledons, called acotyledonous plants (fig. 249). Dicotyledonous plants have exogenous stems (figs. 45, 46, p. 27). Monocotyledonous plants have endogenous stems (figs. 57, 58, p. 37). While acotyledonous plants have acrogenous stems (fig. 64, p. 41), sometimes entirely cellular.

In sowing seeds it is of importance to know the temperature of the soil. The seeds of the common annuals should not be sown until the ground temperature reaches 46° Fahr. Seeds are often preserved in the soil on account of its temperature being higher than that of the air. The winter temperature of the soil, when covered with snow, is in many cases above the freezing-point when melting commences, and is considerably augmented before the dormant vitality of the plant is aroused and germination begins.

The mean temperature of the soil at 2-3 feet is almost throughout the year in India above that of the surrounding atmosphere. This is also shown to be the case in England; and Mr. Thompson found, at Chis-

wick, that the temperature of the soil is, on a mean of six years, at the depth of one foot, 1° above that of the air, and at two feet, 1½°. During the winter months the soil is from 1-2° warmer than the air, and during summer it is a fraction of a degree cooler than the air.

In India the mean temperature of the soil in winter may be often 9-10° above the air. The accumulated heat in the upper strata of soil prevents delicate rootlets from becoming frozen, and preserves the vitality in such fleshy roots as rhubarb and orchids. This temperature is also useful to the burrowing animals, such as marmots and rats, which abound at 15,000 to 17,000 feet above the level of the sea at Tibet. The rapid development of vegetation after the snow is due to the heat of the soil, quite as much as to the increased strength of the sun's direct rays, on lofty regions.

Seeds often remain dormant in the soil, and only germinate when certain changes take place on the surface. When forests are destroyed, it is frequently observed that a new set of plants make their appearance. Oaks and other plants appear in America after the pine-forests have been cleared. Their seeds must have been long in the soil. In Brazil, when a forest has been burned, a different kind of vegetation succeeds that previously in the soil.

Some seeds begin to germinate before they are detached from the plant. This occurs remarkably in the Mangrove Tree (*Rhizophora Mangle*, fig. 29, p. 18), which grows at the muddy mouths of rivers in warm climates. *Coco*-nuts often begin to germinate during a voyage from

the tropics to Britain, and germinating seeds have been found in the interior of gourds.

QUESTIONS.

1. What is meant by germination ?
2. What are the requisites for germination ?
3. What effect has draining upon the soil as regards germination ?
4. What are the effects produced by burying seeds deep in the soil ?
5. Is there sufficient evidence as to the germination of mummy-wheat ?
6. Describe the various stages observed in the malting of barley as illustrating germination.
7. What changes take place in the cotyledons ?
8. Describe the germination of a monocotyledon.
9. Describe the germination of a dicotyledon.
10. Describe the germination of an acotyledon.
11. What is the nature of the stem in dicotyledonous plants ?
12. What is the nature of the stem in monocotyledonous plants ?
13. What is the nature of the stem in acotyledonous plants ?
14. In what way does the soil influence germination ?
15. Mention a peculiarity in the germination of the Mangrove tree.

CHAPTER III.

THE ORGANS OF NUTRITION AND REPRODUCTION IN FLOWERLESS PLANTS.

We have already alluded to the nutritive organs of these plants in so far as regards their acrogenous stems (pp. 40-42) and their acotyledonous embryo (p. 174). Some of them are composed entirely of cells, such as seaweeds, mushrooms, and lichens (figs. 262-266, pp. 183, 184); others have cells and vessels, more especially ladder-like vessels (fig. 9, p. 4). Some have leaves, as mosses; others are leafless, as mushrooms. The leaves of some of these plants bear organs of fructification, as is the case with ferns, and they receive the name of fronds (fig. 251).

In flowerless plants there are no distinct floral organs, such as the calyx, corolla, stamens, and pistil. Certain cellular bodies, however, are found in them, by the union of which reproductive germs equivalent to seeds or to embryo plants are formed.

In *Ferns* there occur little clusters of minute sacs containing what appears to be brown dust, but which in reality consists of microscopic cellules or germs called spores. These, when scattered in favourable situations, have the power of germinating or sprouting, and thus give rise to new plants. The clusters of sacs or spore-

cases are rounded, or linear, or crescent-shaped, and they appear either on the back of the fronds or leaves of ferns, as in the common male shield-fern (fig. 250), and in the lady-fern (fig. 251), or in spike-like processes, as in the royal-fern (fig. 252). The little cases or sacs are frequently surrounded by elastic rings (fig. 253), which open them, and thus allow the spores to be scattered. When the spore germinates it sends out a cell-

Fig. 250.

b Fig. 251. *a*

ular expansion (prothallus), as seen in fig. 254, *p*, and from this arises the proper frond. On this frond-like process, *p*, are developed certain very minute cellular bodies, which are supposed to be equivalent to the stamens and pistils of the flowering plants. In figs. 255 and 256 these organs are seen; the first showing cellular bodies containing moving filaments and repre-

Fig. 250.—Portion of the frond of the male Shield-fern (*Lastrea Filix-mas*), showing two sori, *s s*, or clusters of sporangia or spore-cases covered with a kidney-shaped involucre or indusium attached by the cleft.

Fig. 251.—*Athyrium Filix-fœmina*, Lady-fern. *a*, Entire plant much reduced in size, with root, and frond bearing fructification; *b*, Portion of the frond or leaf magnified to show the fructification.

senting stamens, the second showing a cellular body equivalent to the pistil.

In the common *Horsetail* (*Equisetum*) the little germs or spores are surrounded by four filaments with each of their extremities swollen, as seen in fig. 257. These are hygrometric, and coil round the spore when

Fig. 252.

Fig. 253.

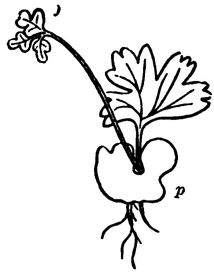


Fig. 254.

moisture is applied, as seen in fig. 258, but spread out when dry, as in fig. 257. They appear to be connected with the placing of the spore in circumstances fit for its growth. These spores form interesting objects under

Fig. 252.—Frond of the Royal-fern (*Osmunda regalis*), bearing pinnæ, *f*. At the extremity of the frond the pinnæ are altered so as to bear fructification, consisting of sporangia arranged in a spike-like manner on a number of short axes.

Fig. 253.—Mature sporangium of the Male-fern (*Lastrea Filix-mas*). It is supported on a stalk, *p*, some of the cells of which form an elastic ring or annulus, *a*, round the spore-case. The spore-case opens at the side to discharge the spores, *s*.

Fig. 254.—Young plant of a Fern (*Pteris paleacea*), showing the commencement of the frond, *f*, arising from a fertilized cell; the early frond (prothallus), *p*, being still attached.

the microscope. When breathed upon, the filaments coil up in a remarkable way, and again expand when dry.

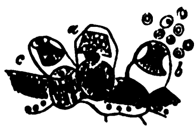


Fig. 255.

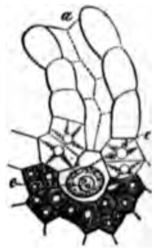


Fig. 256.

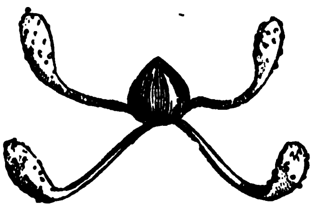


Fig. 257.

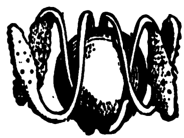


Fig. 258.

In *Mosses* the reproductive organs are only seen in the young state of the plant. When the moss is fully

Fig. 255.—Antheridia (*i.e.* anther-like bodies) from the prothallus of the common brake (*Pteris aquilina*). *a*, An unopened antheridium ; *b*, antheridium bursting at the apex, and discharging free cellules, each containing a moving filament ; *c*, antheridium after the discharge of the cellules.

Fig. 256.—Archegonium (*i.e.* pistil-like body) of the forked spleenwort (*Asplenium septentrionale*). *a*, Canal leading to the large cell, *c*, at the base of the archegonium ; *e*, embryonic cell, whence the proper frond proceeds.

Fig. 257.—Spore of Horsetail (*Equisetum*), surrounded by four filaments with swollen extremities. These filaments are hygrometric.

Fig. 258.—The same spore with the filaments coiled round it after the application of moisture.

developed the germs or spores are contained in urn-like cases, *u* (figs. 259, 260, and 261), covered by a sort of veil, *c*, which falls off and displays a lid, *o*. When this lid is separated, as seen in fig. 261 *o*, there is displayed a series of processes, *p*, called teeth, which are hygrometric, rising up when dry and folding down

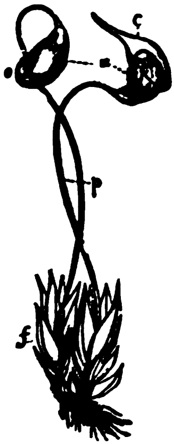


Fig. 259.

Fig. 260.

Fig. 261.

when moist. These teeth are either four in number or some multiple of four, as 8, 16, 64, 256, etc. They surround the top of the case which contains the spores in its interior.

Fig. 259.—A Moss (*Funaria hygrometrica*) slightly magnified. Leaves, *f*, connected with the stalk, *p*; *u*, urn-like spore-case, with its veil, *c*, and lid, *o*.

Fig. 260.—Urn-like case of a Moss (*Encalypta vulgaris*) magnified; *s*, stalk, *c*, veil, under which, and seen through it, are, *u*, the urn-like spore-case, and, *o*, the lid.

Fig. 261.—Urn-like case, *u*, of the same Moss, with the veil removed, and the lid, *o*, taken off to show the row of teeth, *p*; *s*, the stalk bearing the case.

Lichens form the green and yellow coverings of rocks otherwise bare of vegetation. They occur abundantly in temperate and cold regions. They are found on the inhospitable arctic and antarctic rocks, and are the last traces of vegetable life seen on ascending lofty alpine summits. They consist of a cellular expansion bearing rounded discs (fig. 262), which contain tubes with

Fig. 262.

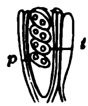


Fig. 263.

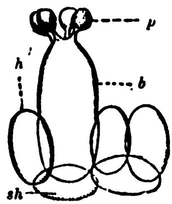


Fig. 264.

spores or germs (fig. 263). The latter are very minute, and are easily carried about by the wind. Lichens are the first plants which appear on coral islands, on lava, or on new islands which occasionally rise in the ocean. They have minute cellular organs of reproduction, visible only under the microscope.

Fungi are illustrated by the mushrooms, toadstools,

Fig. 262.—Lichen (*Parmelia*) with rounded spots of fructification containing tubes with minute germs.

Fig. 263.—A theca or tube, *t*, of a Lichen, containing four nucleated cells. These cells ultimately form sacs containing numerous minute spores. Round the theca are cellular filaments, *p*.

Fig. 264.—Part of the fructification of the Mushroom (*Agaricus campestris*). The cellular stratum, bearing the fructification, is marked *h*, and below it is another set of cells, *sh*. A cell, *b*, bears at its apex four spores, *sp*, which are supported on stalks.

and moulds. They too present little germs attached to various parts of the plants (fig. 264), and sometimes contained in tubes (fig. 265). In an ordinary mushroom (fig. 266) the following parts are seen; a spawn, *my*, consisting of thread-like cells developed underground; from this is produced a stalk, *st*, bearing at its summit a cap-like portion, *p*, on the under surface of which are seen gills or lamellæ, *la* and *h*, on which the

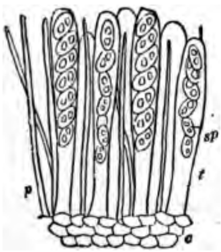


Fig. 265.

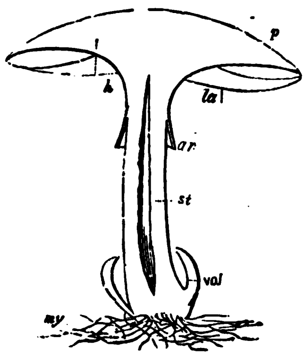


Fig. 266.

young germs are placed. From the edge of the cap there extends to the stalk in a young state a thin cellular membrane called a veil, which is finally ruptured,

Fig. 265.—Vertical section of the fructification of a Fungus (*Peziza*), showing the cellular stratum, *c*, bearing club-shaped spore-cases or thecæ, *t*, which contain nucleated cells, *sp*. Along with the thecæ are cellular filaments, *p*.

Fig. 266.—Vertical section of a Mushroom (*Agaricus campestris*); *my*, mycelium or spawn; *vol*, remains of volva or wrapper, which covers the fructification in the young state; *st*, stipe or stalk, which is hollow internally; *an*, annulus or ring, being the remains of the veil which extended from the edge of the pileus to the stipe; *la*, *lamellæ or* gills, on a cellular base, *h*; *p*, the pileus or cap.

the remains of it forming a ring, *an*, round the stalk. In the very early state of the plant, before it rises upwards, it is enclosed in a wrapper, *vol*, which gives way as the mushroom is developed. In moulds (fig. 267) we observe a spawn, *m*, which extends itself among the decaying matter, and gives rise to a stalk, *f*, which bears the fructification, *s*. The minute germs of fungi are dispersed everywhere throughout the atmosphere, and are ready to alight on any substance in which they can find a nidus. Hence we see mould spring up rapidly wherever there are circumstances favouring its growth. Paste or bread cannot be kept long without becoming mouldy. Fungi grow with astonishing rapidity. Their spawn spreads throughout the soil or decaying matter, and, when circumstances are favourable for their growth, the fructifying stalks spring up from various parts of the spawn. Thus crops of mushrooms appear in the course of a single night. One of the puff-balls has grown in a single night, in damp weather, from the size of a mere point to that of an enormous gourd. By a constant division of cells the production of new ones goes on in geometrical progression. Thus, if one cell becomes 2 in the course of 20 minutes, then in 40 minutes 4 will be found, in 1 hour 8, in 2 hours 64, in 3 hours 512, in 6 hours 262,144, and in $11\frac{3}{4}$ hours upwards of 41,000 millions.

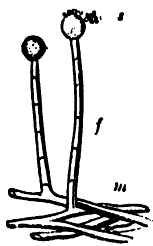


Fig. 267.

Fig. 267.—A species of Mould (*Mucor*) showing the spawn, *m*, bearing a stalk, *f*, ending in a sac, *s*, which encloses numerous very minute spores. The spores are discharged by the bursting of the sac.

The barrack bread at Paris, a few years since, was uneatable twenty-four hours after it had been baked, from the development of a kind of red mould (*Penicillium*) within its substance. Species of coprini or dunghill toadstools occur sometimes on the wood of beds a day or two after they have come from the carpenter's hands. The germs of fungi insinuate themselves into the tissues of animals, and cause their death. Silkworms are liable to a disease called muscardine, which is caused by the attacks of fungi. Wasps in the West Indies suffer in a similar way, so also do caterpillars in Australia. Even man is liable to be attacked by them, and several diseases of the skin and mucous membrane are caused, or at all events modified, by fungi. The diseases of grain, such as smut and rust, are due to a similar cause. Timber, when not well seasoned, and exposed to the attacks of fungi, without proper ventilation, becomes affected with dry-rot, which is owing to the insidious progress of a fungus, the spores or germs of which insinuate themselves into the wood, begin to form their spawn, and thus speedily cause complete decay. The appearance of such a fungus on the walls of houses may be referred to in Leviticus xiv., where a description is given of what is called the leprosy of the house. This plague extended itself over the wood, the stones, and the mortar of the house, and could only be cured by pulling all down. The spawn of some fungi has been found to attack gutta-percha, and cause great injury to telegraph-wires underground. Some telegraph-wires passing under oaks have been thus injured. Some fungi are luminous.

Algæ, or Seaweeds, are plants of a cellular nature, living either in salt or in fresh water, and which have no floral envelopes, and no stamens or pistils. Their reproductive germs are either arranged in clusters of four (fig. 268), or are contained in cases or sacs of various kinds (fig. 269). Some seaweeds are brown-coloured, as the common tangle; others are red, as the dulse; others, as confervæ and lavers, are green; while

Fig. 268.

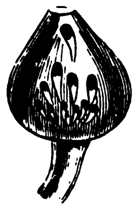


Fig. 269.

a fourth set are very brittle, on account of having a siliceous or flinty covering.

In the common seaweed (*Fucus vesiculosus*), as seen in fig. 270, the frond, *f e*, displays little bladders of air, *v*, which enable it to float, and receptacles of germs, *t*, associated with a slimy sort of mucus. Some seaweeds have stalks several hundred feet long, and their fronds float on the surface of the ocean by means of bladders of air. Some of the fresh-water algæ are composed of simple rows of cells, as seen in fig. 271. These cellular filaments in some instances unite together, as seen

Fig. 268.—Sac containing four germinating spores taken from one of the rose-coloured Seaweeds (*Callithamnion cruciatum*).

Fig. 269.—Part of the fructification of a rose-coloured Seaweed (*Bonnemaisonia asparagoides*). It consists of an ovate sac with a terminal opening, and containing a tuft of pear-shaped germinating cells or spores.

in fig. 272, by means of a tube, *p;* and in this way the contents of one cell pass into another, so as to form a germ or spore, *gr.* In those plants which are familiar to all as forming the green slime of ponds, there are moving filaments observed, as well as moving spores.

Fig. 270.

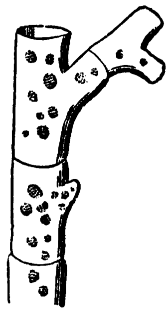


Fig. 271.

The latter, as represented in figs. 273, 274, 275, and 276, are furnished with hair-like processes, which either come off from one point in clusters of two and four (figs. 273 and 274), or more (fig. 275), or they surround the whole spore as with a fringe (fig. 276). These minute hairs exhibit movements for a short time after the spores are separated from the plant; their vibration ceasing

Fig. 270.—Frond, *f e*, of *Fucus vesiculosus*, a common Seaweed; *v*, bladder of air; *t*, cases containing spores and mucus.

Fig. 271.—A Conferva or fresh-water Alga, composed of cells with green cellular matter inside.

whenever the spore becomes fixed and begins to sprout. The brittle algæ called diatoms are remarkable for the division of their cells (fig 277). It has been calculated that, by self-division, one of the diatoms may be propagated at the rate of a thousand millions in a single month. Moreover, by the process of conjugation, cellular

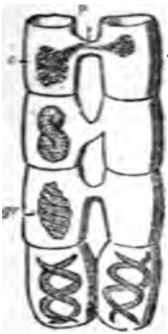


Fig. 272.

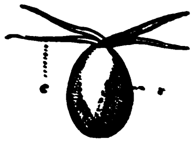


Fig. 273.

Fig. 274.

Fig. 275.

Fig. 276.

bodies, called frustules, are produced, which are very much larger than the ordinary size of the parent, and which multiply also by self-division. Diatoms occur in all parts of the world, and in some places form

Fig. 272.—Two filaments of a fresh-water Alga (*Zygnema*) united by tubes, *p*. The contents of one cell, *c*, pass into another cell, *c*, on the left, and thus the spore, as seen at *gr*, is produced. In the lowest cells moving thread-like bodies are seen.

Fig. 273.—Moving spore of one of the Confervæ (*Chætophora*). The spore consists of a vesicle, *v*, to which are attached four cilia or vibratile filaments, *c*, which move for a certain time after the spore is discharged.

Fig. 274.—Moving spore of Conferva, with two cilia at one end.

Fig. 275.—Moving or swarm spore or zoospore of Conferva, with a tuft of cilia at one end.

Fig. 276.—Moving spore of Vaucheria surrounded by cilia.

enormous deposits. The city of Richmond, in Virginia, is said to be built on a stratum of diatomaceous remains 18 feet in thickness. The substance called Berg-mehl, or Mountain-meal, in Sweden, is composed of fossil diatoms. Their flinty covering prevents them from decaying, and enables them to resist the action of fire and of acids. The markings on many of them are very beautiful, and they constitute excellent test-objects for the microscope.

In red snow an alga is produced called *Protococcus nivalis*, or the red-snow plant. It consists of a minute

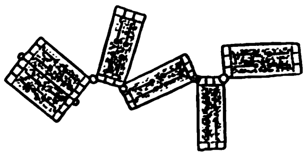


Fig. 277.

globular cyst, resembling in appearance a red currant on a very small scale. The plant is seen in the snow of arctic regions. It is not, however, seen in antarctic regions, nor did Dr. Hooker meet with it on the Himalaya. Blood-rain is due to the presence of an alga called *Palmella prodigiosa*. This plant was developed in less than twenty-four hours, under the eye of Dr. Montagne, in such quantities as to cover cooked provisions with a dark blood-red slime. The red and green colours seen in the ocean and in lakes are owing to the presence of algæ. Some algæ have a

Fig. 277.—Frustules of a diatomaceous Alga (*Diatoma marinum*), separating from each other. The frustules of the plant vary from nearly square to six times as long as broad.

jelly-like appearance, and were formerly supposed to have fallen from the sky, and to be the remains of fallen stars. Hence, species of Nostoc received the names of sky-jelly and star-jelly. The moving or swarm spores or zoospores of algæ are not developed by the ordinary process of reproduction, namely by antheridia and archegonia, but may be considered as separable cells or cellular germs giving rise to new individuals. There are also in the red seaweeds resting or motionless spores, produced in the same way, and formed in fours in special sacs (fig. 268).

QUESTIONS.

1. What is meant by flowerless plants, and what other names are given to them?
2. Describe the ordinary fructification of ferns.
3. What is meant by spores?
4. What functions do spores perform?
5. In what organ are spores contained?
6. In the common male shield-fern where are spore-cases found?
7. How do spore-cases burst and scatter the spores?
8. How do spores germinate?
9. What kind of organs are found in ferns equivalent to stamens and pistils?
10. Describe a peculiarity in the spores of the horsetail.
11. Describe the fructification of a moss.
12. What is meant by the teeth of mosses?
13. What numbers have been noted in the teeth of mosses?
14. What is meant by the lid in the fructification of mosses?
15. What are lichens?
16. In what kind of climate do they abound?

17. Mention plants belonging to the fungi.

18. Describe the parts of an ordinary mushroom.

19. What is the spawn of mushrooms ?

20. What are the gills of a mushroom, and what do they bear on their surface ?

21. What is meant by the veil of a mushroom ?

22. What is the wrapper of a mushroom ?

23. What is mould ?

24. Mention any remarkable facts in the growth of fungi.

25. Are fungi in any way connected with diseases ?

26. What is muscardine ?

27. What are algæ ?

28. Describe their fructification.

29. What colours are found in seaweeds ?

30. Is there any apparatus for enabling seaweeds to float ?

31. What movements have been observed in the spores of algæ ? What are zoospores ?

32. What are diatoms ?

33. Explain conjugation in certain algæ.

34. What constitutes the Mountain-meal (Berg-mehl) of Sweden ?

35. What kind of covering is found in diatoms ?

36. How do diatoms divide ?

37. What plant is found in red snow ?

38. What is the nature of blood-rain ?

39. What is meant by sky-jelly and star-jelly ?

PART II.

THE ARRANGEMENT OR CLASSIFICATION OF PLANTS.

CHAPTER I.

GENERAL REMARKS ON CLASSIFICATION.

In examining the vegetable kingdom, we observe that the individuals composing it are formed by the Almighty in accordance with a principle of order, as well as a principle of special adaptation. We have already remarked the order pursued in the arrangements of the various parts of the root, stems, leaves, and flowers of plants, and we have traced, in some degree, the modes in which they are fitted to perform their different functions. We now proceed to apply the facts of vegetable anatomy and physiology to the classification of plants, and to consider the plan according to which they are grouped together in classes and families.

We see around us various kinds or sorts of plants, more or less resembling each other—or, in other words, more or less related to each other. In systematic botany we endeavour to mark these resemblances, and to determine their relations. It is impossible to give a scientific arrangement of the plants of the globe without a thorough knowledge of structure, and

without an extensive acquaintance with the vegetation of all parts of the world. We cannot expect to determine the system on which plants have been grouped until we are familiar with all the forms which they present. Hence, in the present state of our knowledge, there must be imperfection in our attempts at systematising. The floras of many regions in Africa, India, China, Australia, and America, are still unknown, and we may therefore conclude that in all systems there will be gaps, to be filled up as our knowledge increases. Sufficient, however, is known to enable us to group plants according to certain evident alliances.

The necessity for arrangement is evident, when we reflect that there are more than 150,000 known species of plants on the earth. In order to make these available for scientific purposes, it is absolutely essential that they should be named and classified. In associating plants in certain groups, we naturally proceed on an idea of resemblance or likeness. While in ordinary language this idea is vague and indefinite, in scientific language it must be strict and precise. It is not enough to say that one plant resembles another in its general aspect, we must ascertain the particulars of agreement, and the points in which they differ; we must weigh well the importance of the characters, and must compare organs which are equivalent in value; and thus we shall often find, that plants which to common observers appear alike are in reality totally different. The study of the anatomy of plants gives us a strict and accurate technical language, which must be *rigidly* adhered to in classification.

Plants as they occur in nature, are viewed as individuals resembling or differing from each other. Some individuals are so decidedly alike that we at once give them the same names. Thus a field of wheat is composed of numerous similar individuals which can be separated from each other, but cannot be distinguished by any permanent or marked difference. Although there may be some variation in size and other minor points, still we at once say they are stalks of wheat. Every grain of wheat, when sown, produces a stalk of wheat; these stalks yield grains, which produce individuals like their parents. The shoots or buds given off from the base of wheat-plants by tillering also produce stalks of wheat. On such universal and inevitable conceptions as these, our ideas of *Species* are founded.

Looking at the present vegetation of the globe, a species may be defined as an assemblage of individuals presenting certain constant characters in common, and derived from one original stock. For each species we believe that there has been a parent stock, which has given origin to a succession of similar individuals. They may differ slightly in size, or in colour, and other unimportant respects, but they resemble each other more closely than they resemble any other plants, and their seeds produce similar individuals. Observation and common daily experience demonstrate, in the actual circumstances in which we exist, the permanence of the types which constitute the species of living bodies. There is no evidence whatever of a transmutation of species. The erroneous statements regarding the con-

version of oats into rye have arisen from imperfect observations. The individuals, however, of a species may present certain differences in regard to size, colour, etc., these differences depending on soil, and on different conditions of heat, light, and moisture. Such differences are not incompatible with the idea of a common origin; and, moreover, there is always a tendency to return to the original type. Some, however, suppose that species are not fixed, but that they are transitive forms, derived by a process of so-called natural selection from those which existed at former epochs of the earth's history. We shall not enter here into the speculations relating to the origin of species. We may indulge in conjectures as to the mode in which species have been formed, but we have not yet been able to fathom the depths of God's doings in the creation and perpetuation of species.

What are called *Varieties* are variations in species which are not in general of a permanent character, and cannot be kept up in ordinary circumstances by seed. By cultivation, however, such varieties are sometimes perpetuated. This is usually accomplished by means of cuttings or grafts, and in certain instances even by seed. Thus the varieties of the cereal grains and of culinary vegetables have been propagated so as to constitute permanent *Races.*

Plants under cultivation are liable to *sport,* as it is called, and the peculiarities and variations thus produced are sometimes kept up. All the varieties of cabbage, cauliflower, brocoli, savoys, and curled greens, *are derived* from one stock—*Brassica oleracea.* This

plant grows wild on the sea-shore, and when cultivated it undergoes remarkable changes. Thus it forms a heart, as in ordinary cabbage; its flower-stalks become thickened and shortened, as in cauliflower and brocoli; or its parenchyma is largely developed between the vessels, so as to give rise to the crisp and curled appearance of greens. This tendency in the plant to produce monstrosities was early noticed by cultivators, and care was taken to propagate those individuals which showed abnormal appearances. The seeds of such were saved, put into good soil, and no plants were allowed to remain except such as presented the required form. In this manner certain races of culinary vegetables have been established. If, however, these cultivated plants are allowed to grow wild and scatter their seed in ordinary soil, we believe that they will, in the progress of time, revert to the original type or species. Instances such as these show the remarkable effects of cultivation in perpetuating varieties by seed. In regard to the cereal grains—wheat, barley, oats, etc.—they have been so long cultivated that we are at a loss to know the original types or species. We have been forced, in the meantime, to call them species, although they are probably mere cultivated varieties of unknown species, perpetuated as races.

It is of great importance to distinguish between mere varieties and true species, and to determine the limits of variation in different species. By not attending to this, many mere varieties have for the time been described as species, and thus great confusion and incorrectness have arisen both in descriptions and in

arrangements. Another source of fallacy arises from hybrids being occasionally reckoned as true species.

Certain species, not identical in origin, have common features of resemblance, and are associated together under what is called a *Genus.* A genus, then, is an assemblage of nearly-related species, agreeing with one another, in general structure and appearance, more closely than they accord with other species. Thus the Scotch rose, the Dog rose, the China rose, and the sweet-brier, are all different species included in one genus, Rosa. It may happen that a single species may be reckoned as forming a genus, when the peculiarities are as marked as those constituting other genera. Thus, if there was only one species of oak, it would be sufficient to constitute a genus, as much so as at present when it includes 200 species. It is distinguished by its acorn from other allied genera, such as the beech, the hazel, and the chestnut. The species in a genus present one general plan, and may be said to be formed after the same pattern. Some species of a genus, having special points of resemblance, may be grouped together in a *Sub-genus.*

On looking at genera, it will be seen that some of them, such as oaks, hazels, beeches, and chestnuts, have a strong resemblance or family likeness, and that they differ remarkably from such genera as firs and pines, maples and ashes. Certain genera may in this way be grouped so as to form *Orders* or *Families.* While genera are groups of allied species, orders are groups of allied genera, or, in reality, more comprehensive genera. *Thus, firs,* pines, and larches belong to different genera,

but all agree in being cone-bearing, and are grouped under Coniferæ. The rose, the raspberry, the bramble, the strawberry, the cinquefoil, the cherry, and the plum, all agree in their general form and structure, and are united under Rosaceæ. Certain genera have more points in common than others, and are grouped together under subdivisions of orders called *Sub-orders.* Thus, the plum and the cherry have a drupe as their fruit, and are more nearly allied to each other than they are to the apple ; again, the strawberry, raspberry, and bramble, are more allied to each other than to the cherry or apple. We have thus Sub-orders of Rosaceæ —namely, Amygdaleæ, including the plum, peach, cherry, and almond ; Pomeæ, including the apple, pear, medlar, and quince ; Potentilleæ, including the strawberry, cinquefoil, and raspberry ; and Roseæ, comprehending the roses.

Certain orders, agreeing in evident and important general characters, are united together so as to form *Classes;* and subdivisions of classes are made in the same way as in the case of orders. There are thus *Sub-classes* associating certain orders included in one class.

The usual divisions are thus, Classes, Orders, Genera, and Species. These occur in all systems of classification. A more minute subdivision may be made as follows :—

I. Classes.
  a. Sub-classes.
II. Orders or Families.
  a. Sub-orders.
  b. Tribes.
  c. Sub-tribes.

III. Genera.
  a. Sub-genera.
IV. Species.
  a. Sub-species.
  b. Varieties.
  c. Races.

An enumeration of the marks by which one Class, Order, Genus, or Species, is distinguished from another is called its Character. In giving the characters of any division, we notice merely those which are necessary to distinguish it from others. This is called the *Essential Character.* A plant may also be described completely, beginning at the root, and proceeding to the stem, branches, leaves, flowers, fruit, seed, and embryo. This is not essential, however, for the purpose of classification, and would be quite superfluous in that point of view. In the character of the classes the important points of structure on which they are constituted are given. In the character of orders (the ordinal character) we give the general structure of the included plants, especially of their flowers and fruit. In the generic character we notice the modification of the ordinal character in a given genus—the character being taken from the parts of the flower and fruit, as in the order. In the specific character are included certain less important modifications of form, whether in the stem, leaves, or flowers, which serve to distinguish allied species.

The essential character of a genus, when given in Latin, is put in the nominative case, that of a species in the ablative. The names of the classes are variously derived, according to the views of the authors in regard to classification. They express some points of structure or development which are of marked importance or permanence. The orders are named from some characteristic genus included in them, except in *artificial methods,* where some organ is taken as the means

of distinction. Genera are derived either from the Latin name of one of the species, from the structure or qualities of the included species, or from the name of some botanist, etc. Thus Prunus is a genus including the plum, the sloe, etc.; Rosa, the rose; Papaver, the poppy; Hookeria is a genus named after Hooker; Lithospermum, from two Greek words signifying a stone and seed, is given to a genus, the species of which have hard stony achenes.

In giving the name of a plant, we mention its genus and species. Thus the common Dog-rose is called *Rosa canina*, the first being the generic name, the second the specific. Specific names may indicate the country in which a plant is found, the locality in which it grows, the form of its roots, stem, or leaves, the colour of its flowers, etc. A species named in honour of its discoverer or describer has the specific name usually in the genitive, as *Veronica Jacquini* named after Jacquin. When the name is given in compliment to a botanist, without reference to the discovery, then the specific name is in the adjective form, as *Veronica Lindleyana.* Sometimes a generic name is used specifically, and then it is put as a noun after the genus, with a capital letter, and the two names may not agree in gender; thus we have such names as *Cratægus Oxyacantha, Æthusa Cynapium, Viburnum Opulus, Veronica Chamædrys.* To the genus and species are added certain letters indicating the botanist who founded them. Thus *Valeriana, L.* is the genus Valerian as constituted by Linnæus; and *Valeriana officinalis, L.* is the officinal Valerian as described by

Linnæus; *Oxytropis, DC.*, is the genus so called by De Candolle.

The following formulæ have been proposed for the purpose of expressing the arrangements of the parts of the flower. The several whorls are represented by letters, thus:—S means sepals, P = petals, St = stamens, C = carpels. The parts constituting the different parts of the whorl are marked by numbers placed after each of the letters. Thus the formula:—$S_5P_5St_5C_5$ means that the flower is perfect and pentamerous, each of its whorls consisting of 5 members, viz. 5 parts of the calyx and 5 of the corolla, 5 stamens, and 5 carpels forming the pistil. This may be seen in the case of the common flax (*Linum*). If any of the whorls, such as the staminal whorl, consisted of 10 in place of 5 parts, then the formula would be—$S_5P_5St_{5+5}C_5$. This would indicate that while the parts of the calyx, corolla, and pistil, are arranged in single whorls of five parts, the stamens are arranged in two alternating whorls of five. This may be seen in the stonecrop (*Sedum*).

The following formula will represent the decussate arrangement in the flowers of *Maianthemum bifolium*, a kind of Solomon's seal:—$S_2P_2St_{2+2}C_2$. There is here a decussate arrangement by twos, and the stamens are in 2 whorls of 2 each.

To represent the flower of the lily (*Lilium*) the following formula may be given:—$S_3P_3St_{3+3}C_3$. This indicates 3 sepals (or parts of the outer perianth), 3 petals (or parts of the inner perianth), 6 stamens in *two rows of 3* each, and 3 carpels forming the pistil.

In the case of the nettle (*Urtica*), where the whorls are not complete, the staminate flower is represented thus: $S_4P_0St_4C_0$. In this case the calyx is formed of 4 members, the petals are wanting, the stamens are 4, and the carpels (pistil) wanting. The flower is therefore monochlamydeous and staminate. While, again, the pistillate flower of the nettle has this formula—$S_2P_0St_0C_1$. This indicates 2 parts of the calyx, no petals, no stamen, and 1 carpel. While the absence of a whorl is indicated by the symbol (0), the absence of any member of a whorl is marked with a dot (•). If there are more than one member absent, then the number of dots will indicate this, and the arrangement of the dots will show the position of the absent parts.

The formula for an orchis flower in its fully expanded state is given thus:—$S_3P_3St_{\underset{\cdot\cdot}{1}+0}C_3$. There are 3 parts of the calyx and 3 of the corolla, the inner row of stamens is wanting, while the outer row consists of one perfect stamen and two abortive stamens, marked ••; the dots being placed so that the imperfect stamens are shown to be inferior, while the perfect one is superior.

In an orchid called Lady's-slipper (*Cypripedium*) the formula for its fully developed flower is as follows:—$S_3P_8St_{0+\underset{\cdot}{2}}C_3$. In this case the outer staminal whorl is wanting, but the inner consists of two perfect stamens placed above, and one imperfect stamen below, marked by a dot.*

* These formulæ represent orchideous flowers in their fully expanded condition. It must be borne in mind, however, that these flowers are actually turned round by a twisting of the ovary on which they are supported, so that the parts which are superior in the young state become inferior when the flower is fully developed.

To indicate that the parts of a whorl are united or coherent, the symbol $\frown$ is used. Thus :—$\overset{\frown}{S}$ means united or coherent sepals, the calyx being gamosepalous. $\overset{\frown}{P}$ means united or coherent petals, the corolla being gamopetalous. $\overset{\frown}{St}$ means that the stamens are united or coherent, the flower being gamostemonous (monadelphous or syngenesious). $\overset{\frown}{C}$ means that the carpels are united or coherent throughout, being gamocarpellary (syncarpous). Thus, $\overset{\frown}{S}_5 P_5 St_{\overset{\frown}{5+5}} \overset{\frown}{C}_5$ means a flower with 5 coherent sepals, 5 free or non-coherent petals, 10 stamens coherent in two rows of 5 each, and 5 coherent carpels. This formula will apply to many plants of the Mallow order (Malvaceæ).

The formula for a speedwell (*Veronica*) will be $\overset{\frown}{S}_4 \overset{\frown}{P}_4 St_2 \overset{\frown}{C}_2$. That means calyx of 4 coherent sepals, corolla of 4 coherent petals, stamens 2, not coherent, carpels 2, coherent.

The formula for the blossom of a convolvulus will be :—$S_5 \overset{\frown}{P}_5 St_5 \overset{\frown}{C}_2$. That is, 5 sepals, 5 coherent petals, 5 stamens, and 2 coherent carpels.

The formula for a pea-blossom (a papilionaceous flower) is given thus :—$\overset{\frown}{S}_5 P_5 St_{\overset{\frown}{5+4}+1} C_1$. This means that there are 5 parts of a gamosepalous calyx, 5 petals, 5 stamens of the outer whorl and 4 of the inner whorl have united into a tube, while the posterior stamen of the inner whorl is free, and the pistil is formed of one carpel.

Various other matters may be embraced in such *formulæ.* For instance, the superposition (opposition)

of parts in two whorls which are next each other is marked by a perpendicular line between the two, thus: $\widehat{S_5}\widehat{P_5} \mid St_5\widehat{C_5}$. This case may represent the primrose, in which the stamens are superposed or opposite to the parts of the corolla, the superposition being indicated by the line.

The preparation and application of these formulæ is a useful exercise for a pupil, and the full consideration of them may be delayed until the natural orders come under examination. A teacher may therefore conveniently postpone them till a more advanced period of a course.

QUESTIONS.

1. What idea guides us in the grouping of plants?
2. What is meant by a species? Give an example.
3. What is meant by a variety? Give an example.
4. What is meant by races of plants? Give an example.
5. What is meant by a genus? Give an example.
6. What is meant by an order? Give an example.
7. What is meant by a sub-order? Give an example.
8. What is meant by a class? Give an example.
9. What is meant by a sub-class? Give an example.
10. What is the origin of the cultivated cabbage, cauliflower, and greens?
11. How is cauliflower produced? What is the part of the plant used for food?
12. What is meant by the essential character of a species or genus?
13. What is meant by the letter or letters placed after a genus or species?

14. Give an instance of a generic name.

15. Give an instance of a specific name.

16. Explain the abbreviations S, P, St, and C, as used in descriptive formulæ.

17. Explain the abbreviations $\overset{\frown}{S}$, $\overset{\frown}{P}$, $\overset{\frown}{St}$, $\overset{\frown}{C}$

18. Explain the following formula :—$\overset{\frown}{S}_5\, P_5\, St_5\, \overset{\frown}{C}_5$

19. Explain the following formula :—$S_3\, P_3\, St_{3\,+\,3}\, \overset{\frown}{C}_3$

20. Explain the following formula :—$S_3\, P_3\, St_{\underset{\cdot}{0}{:}+\underset{\cdot}{2}}\, \overset{\frown}{C}_3$

21. Explain the following formula :—$\overset{\frown}{S}_5\, P_5\, St_{5\overset{\frown}{+}4\,+\,1}\, C_1$

22. Explain the following formula :—$S_3 P_3 St_{\underset{..}{1}\,+\,0}\, \overset{\frown}{C}_3$

CHAPTER II.

SYSTEMS OF CLASSIFICATION.

THERE are two systems pursued in the arrangement of plants; one is called the Artificial method, and the other the Natural method. The higher divisions of classes and orders in these systems are founded on entirely different principles, while the genera and species, or the minor divisions, are the same in both. The genera and species are very differently arranged in the two systems. In artificial methods one or two organs are selected in an arbitrary manner, and they are taken as the means of forming classes and orders; while in the natural method plants are grouped according to their alliance in *all* their important characters. Plants belonging to the same class and order in the former system may have nothing in common except the number of the stamens and pistils, or the form of their flowers, or some other arbitrarily-selected character; while in the latter, plants in the same class and order are related by true affinity, and correspond in all the essential points of their structure. When a student knows the artificial class and order to which a plant is to be referred, he does not thereby become acquainted with its structure and properties; plants diametrically opposed in these respects may be associated together. When

he determines, on the other hand, the place of a plant in the natural system, he necessarily acquires a knowledge of its structural relations and affinities. Hence a knowledge of the latter system must be the aim of the botanical student.

I.—Artificial Systems of Classification.

Attempts at an artificial methodical arrangement of plants were made by Cæsalpinus, Morison, Rivinus, and Tournefort, but the system generally adopted was that of Linnæus, founded on the essential organs of reproduction in plants. It is called an artificial method, because it takes into account only a few marked characters in plants, and does not propose to unite them by natural affinities. It is an index to a department of the book of nature, and as such is useful to the student. It does not aspire to any higher character, and although it cannot be looked upon as a scientific and natural arrangement, still it has a certain facility of application which commends it to the tyro. In using it, however, let it ever be remembered that it will not of itself give the student any view of the true relations of plants as regards structure and properties, and that, by leading to the discovery of the name of a plant, it is only a stepping-stone to the natural system.

In the artificial system of Linnæus, plants are divided into Flowering and Flowerless—the latter being included in the twenty-fourth class, under the name of Cryptogamia, and the former, or Phanerogamia, *being divided* into twenty-three classes, the characters

of which are founded on the number, the insertion or position, the relative length, and the connection of the stamens. Among flowerless plants the orders are similar to those of the natural system, while in flowering plants they are determined by the number of the styles, the character of the fruit, the number and connection of the stamens in the classes where these characters are not already taken into consideration, and on the perfect or the incomplete nature of the flowers as regards stamens and pistils.

The following are the Classes of the Linnæan artificial system :—

A. Flowering Plants, Phanerogamia.

I. Stamens and Pistils in every flower.

1. Stamens unconnected.

a. Stamens either of equal length, or at all events neither didynamous nor tetradynamous :—

1 in number in each flower . Class I. Monandria.
Examples.—Mare's-tail, red valerian.

2 in number in each flower . Cl. II. Diandria.
Ex.—Speedwell, privet, ash.

3 in number in each flower Cl. III. Triandria.
Ex.—Iris, grasses, common valerian.

4 in number in each flower Cl. IV. Tetrandria.
Ex.—Lady's-mantle, bedstraw, plantago.

5 in number in each flower Cl. V. Pentandria.
Ex.—Primrose, violet, hemlock, harebell.

6 in number in each flower Cl. VI. Hexandria.
Ex.—Tulip, lily, hyacinth, rush.

7 in number in each flower Cl. VII. Heptandria.
Ex. — Chickweed winter-green, horse-chestnut.

8 in number in each flower Cl. VIII. Octandria.
Ex.—Heath, blaeberry, herb-paris.

9 in number in each flower Cl. IX. Enneandria.
Ex.—Flowering-rush (Butomus).

Stamens 10 in number in each flower . Cl. X. Decandria.
Ex.—Saxifrage, pink, stonecrop.

12 to 19 in number in each flower . } Cl. XI. Dodecandria.
Ex.—Mignonette, agrimony.

20 or more on the calyx. Cl. XII. Icosandria.
Ex.—Rose, strawberry, pear, cactus.

20 or more on the receptacle. Cl. XIII. Polyandria.
Ex.—Buttercup, anemone, poppy.

b. Stamens differing in length in certain proportions :—

2 long and 2 short . Cl. XIV. Didynamia.
Ex.—Dead-nettle, frogsmouth, figwort.

4 long and 2 short (flower cruciform) . . } Cl. XV. Tetradynamia.
Ex.—Wallflower, shepherd's-purse, draba.

2. Stamens connected—

By their filaments in one parcel or tube . . } Cl. XVI. Monadelphia.
Ex.—Geranium, mallow, hollyhock, cotton.

By their filaments in two parcels, usually papilionaceous . . . } Cl. XVII. Diadelphia.
Ex.—Vetch, clover, fumitory.

By their filaments in three or more parcels. } Cl. XVIII. Polyadelphia.
Ex.—St. John's wort.

By their anthers (composite flowers) . . } Cl. XIX. Syngenesia.
Ex.—Dandelion, daisy, thistle, groundsel.

With the pistil on a column Cl. XX. Gynandria.
Ex.—Orchis, birthwort.

II. Stamens and pistils in separate flowers—

On the same plant . Cl. XXI. Monœcia.
Ex.—Hazel, sedge, euphorbia, arum.

On two separate plants . Cl. XXII. Diœcia.
Ex.—Willow, poplar, hop, hemp.

III. Stamens and pistils in the same and in separate flowers on the *same* or on separate plants . } Cl. XXIII. Polygamia.
Ex.—Orache, sea-purslane, pellitory.

B. Flowerless Plants.

Organs of reproduction inconspicuous . .	Cl. XXIV. Cryptogamia.
	Ex.—Ferns, mosses, seaweeds, mushrooms.

The following are the Orders of the Linnæan system. In the first thirteen Classes the number of free styles determines the Order.

Class			
I. II. III. IV. V. VI. VII. VIII. IX. X. XI. XII. XIII.	Order 1.	Monogynia . . .	1 free style.
		Examples.—Primrose, speedwell.	
	2.	Digynia	2 free styles.
		Ex.—Pink, grasses, saxifrage.	
	3.	Trigynia	3 ,,
		Ex.—Chickweed, sandwort, catchfly.	
	4.	Tetragynia . . .	4 free styles.
		Ex.—Herb Paris.	
	5.	Pentagynia . . .	5 ,,
		Ex.—Stonecrop, campion, columbine, flex.	
	6.	Hexagynia . . .	6 free styles.
		Ex.—Flowering rush (Butomus).	
	7.	Heptagynia . . .	7 ,,
		Ex.—Septas.	
	8.	Octogynia . . .	8 ,,
	9.	Enneagynia . . .	9 ,,
	10.	Decagynia . . .	10 ,,
		Ex.—Poke-weed (phytolacca).	
	11.	Dodecagynia . . .	11 to 19
		Ex.—Houseleek.	
	12.	Polygynia . . .	20 or more.
		Ex.—Strawberry, crowfoot, rose, cinquefoil.	

In Classes XIV. and XV. the Orders are determined by the fruit.

Class			
XIV.	Order 1.	Gymnospermia . .	Fruit, Achenes.
		Ex.—Dead-nettle, mint, labiate plants.	
	2.	Angiospermia . .	Fruit, Capsular.
		Ex.—Foxglove, frogsmouth, figwort.	

Class XV.

Order 1. Siliculosa . . . Fruit, a Silicula.
Ex. — Scurvy-grass, shepherd's-purse, draba.
2. Siliquosa . . . Fruit, a Siliqua.
Ex.—Wallflower, stock, mustard.

In Classes XVI. XVII. and XVIII., the Orders are determined by the number of stamens, as in some of the Classes.

Class XVI.

Order Pentandria . . . 5 stamens.
Ex.—Passion-flower, erodium.
Octandria . . . 8 ,,
Ex.—Milkwort.
Decandria . . . 10 ,,
Ex.—Geranium.
Polyandria . . . Numerous stamens.
Ex.—Mallow.

XVII.

Order Hexandria . . . 6 stamens.
Ex.—Fumitory.
Decandria . . . 10 ,,
Ex.—Broom, pea.

XVIII. Order Polyandria . . . Numerous stamens.
Ex.—St. John's wort.

XIX.*

Order 1. Polygamia æqualis, florets all ☿.
Ex.—Dandelion, chicory.
2. Polygamia superflua, florets of the disk ☿; those of the ray ♀, but fertile.
Ex.—Daisy, aster.
3. Polygamia frustranea, florets of the disk ☿; those of the ray abortive.
Ex.—Corn blue-bottle.
4. Polygamia necessaria, florets of the disk ♂; those of the ray ♀, and fertile.
Ex.—Marigold. None British.
5. Polygamia segregata, each floret having a separate involucre.
Ex.—Globe-thistle. None British.

* For an explanation of the symbols in the 19th and 23d *Classes, see p. 148.*

In Class XX. the Orders are founded on the number of the stamens.

Class	Order		
XX.	Order Monandria	1 stamen.	*Ex.*—Orchis, habenaria.
	Diandria	2 stamens.	*Ex.*—Stylewort, lady's-slipper.
	Hexandria	6 ,,	*Ex.*—Birthwort.

In Classes XXI. and XXII. the Orders are founded on the number as well as on the union of the stamens.

Class	Order		
XXI.	Order Monandria	1 stamen.	*Ex.*—Euphorbia.
	Diandria	2 stamens.	*Ex.*—Duckweed.
	Triandria	3 ,,	*Ex.*—Carex, maize, typha.
	Tetrandria	4 ,,	*Ex.*—Birch, alder, box.
	Hexandria	6 ,,	*Ex.*—Coco-nut and some other palms.
	Octandria	8 stamens.	*Ex.*—Hazel.
	Polyandria	Numerous stamens.	*Ex.*—Oak, chestnut.
	Monadelphia	Stamens monadelphous	*Ex.*—Fir, spruce, larch.
	Polyadelphia	Stamens polyadelphous.	*Ex.*—Castor-oil plant.
XXII.	Order Diandria	2 stamens.	*Ex.*—Willow.
	Triandria	3 ,,	*Ex.*—Date-palm.
	Tetrandria	4 ,,	*Ex.*—Nettle, gale, mistleto.
	Hexandria	6 ,,	*Ex.*—Black bryony, smilax.

Class	Order	
XXII.	Order Octandria . . .	8 stamens.
	Ex.—Poplar.	
	Enneandria . .	9 ,,
	Ex.—Mercurialis.	
	Polyandria . .	Numerous stamens.
	Ex.—Poterium, cycas.	
	Monadelphia .	Stamens monadelphous.
	Ex.—Yew, nutmeg.	

In Class XXIII. the Orders are founded on the fact of the perfect, staminate, and pistillate flowers being all on one plant or on more than one.

Class	Order
XXIII.	Order Monœcia, ☿, ♂, and ♀, on the same plant.
	Ex.—Sea-purslane, mimosa.
	Diœcia, ☿, ♂, ♀, on two plants.
	Ex.—Fig.
	Triœcia ☿, ♂, ♀, on three plants.
	Ex.—Orache.

In Class XXIV. the Orders are the same as in the natural system.

Class	Order
XXIV.	Order 1. Filices, ferns.
	2. Musci, mosses.
	3. Hepaticæ, liverworts.
	4. Lichenes, lichens.
	5. Algæ, seaweeds.
	6. Fungi, mushrooms.

The system of Linnæus, even when regarded simply as an index to the vegetable kingdom, is by no means complete. The parts of flowers often vary in number, and cannot be confined within the strict rules required by this method of arrangement; moreover, unless the stamens and pistils are perfect and complete, and the plant is in full flower, it is impossible to determine its class and order. When the system is rigidly adhered to, we find that species belonging to the same genus

are separated. Thus, most of the species of the genus Lychnis have ten stamens and five styles in each flower, but there is at least one British species diœcious. In order, therefore, to keep the genus entire, and not separate the species, Linnæus adopted the plan of putting Lychnis in the class Decandria and order Pentagynia, and under the class Diœcia, order Decandria, placing the name of the diœcious species, and referring the student to the tenth class for a description. In this way the genera—which are founded on natural affinities, and are not constructed by a mere arbitrary method—are preserved in their integrity. All the species of one genus are placed together, whether they accord or not with the characters of the class and order; the place of the genus being determined by the characters of the majority of the species. The names of the anomalous species are given in italics, in the classes and orders to which they belong according to the Linnæan method, and reference is made to the description of them as given under the genus.

QUESTIONS.

1. What is meant by an artificial system of classification?
2. What is meant by a natural system of classification?
3. Compare these two systems.
4. On what characters are the Linnæan classes founded?
5. On what characters are the Linnæan orders founded?
6. Enumerate the classes in the Linnæan system.
7. Give the characters of the first 11 classes.
8. Give the characters of the 12th and 13th classes.
9. Give the characters of the 14th and 15th classes.
10. Give the characters of the 16th, 17th, and 18th classes.

11. Give the character of the 19th class.
12. Give the character of the 20th class.
13. Give the characters of the 21st, 22d, and 23d classes.
14. Give the character of the 24th class.
15. In which of these classes may we expect to find plants with four stamens?
16. In which of them may we expect to find plants with six stamens?
17. Give examples of the Linnæan orders as found in the first 13 classes.
18. Describe the orders in the 14th class.
19. Describe the orders in the 15th class.
20. Describe the orders in the 16th, 17th, and 18th classes.
21. Describe the orders in the 19th class.
22. Describe the orders in the 20th class.
23. Describe the orders in the 21st and 22d classes.
24. Describe the orders in the 23d class.
25. Enumerate the orders in the 24th class.

II.—Natural System of Classification.

In arranging plants according to the Natural System, the object is to bring together those which are allied in all essential points of structure. It is called natural, because it professes to follow the system of Nature, and thus takes into account the true affinities of plants on a comparison of all their organs. One of the first natural methods of classification was that proposed by Ray about 1682. He separated flowering from flowerless plants, and divided the former into Dicotyledons and Monocotyledons. His orders were founded on correct views of the affinities of plants, and he far outstripped his contemporaries in his enlightened views of

arrangement. He may be said to have laid the foundation of that system which has been elucidated by the labours of Jussieu, De Candolle, Brown, Lindley, Endlicher, and others.

In arranging plants according to a natural method, we require to have a thorough knowledge of structural and morphological botany, and hence we find that the advances made in these departments have materially aided the efforts of systematic botanists. We may regard plants in various points of view, either with reference to their elementary tissues, their nutritive or their reproductive organs. The first two are the most important, as being essential for the life of individuals, while the latter are concerned in the propagation of the species. These sets of organs bear a certain relation to each other, and we find that plants may be associated by a correspondence in all of them. In comparing the characters of plants, we must take care that we contrast organs belonging to the same class of functions, and the value of the characters must depend upon the importance of the functions performed by the organs.

Cellular tissue is reckoned of the highest value, as being of universal occurrence, and as carrying on, in many instances, all the functions of plants. In considering the elementary tissues alone, we divide all plants into Cellular and Vascular—the former including the lower tribes of flowerless plants, such as lichens, seaweeds, and mushrooms; the latter including the higher flowerless plants with scalariform vessels, and all the flowering plants. In the nutritive and reproductive organs there is nothing which can be considered of the

same value as cellular tissue. In the nutritive organs the embryo occupies the highest place, and by examining it we divide plants into Acotyledonous, having no cotyledons, but occasionally producing a cellular expansion (prothallus); Monocotyledonous, with one cotyledon; and Dicotyledonous, with two cotyledons. Proceeding to the secondary organs in the nutritive class, we find the stem is Cellular or Thallogenous, Acrogenous, Endogenous, and Exogenous. The thallus is veinless, the fronds of Acrogens have often a forked venation, the leaves of Endogens are parallel-veined, and those of Exogens reticulated. In the reproductive system the stamens and pistils occupy the highest place, as being the essential organs of flowering plants (Phanerogamia), while peculiar cells (antheridia and archegonia) have the same value in flowerless plants (Cryptogamia). Succeeding these organs in value comes the fruit, which is either a theca with spores, or a pericarp with seed. The floral envelopes are the next in the series; they are absent in Cryptogamous plants, and present in Phanerogamous; their arrangement is ternary in Monocotyledons, quinary and binary or quaternary in Dicotyledons.

We thus find that, by comparing these different organs in plants, we arrive at certain great natural divisions, including plants which are associated by affinity of structure and function, as exhibited in the following Table:—

Cellular Plants without Vessels or Stomata.	Vascular Plants with Scalariform Vessels and Stomata.	Vascular Plants with Spiral Vessels and Stomata.	
Acotyledonous	Acotyledonous, with Prothallus.	Monocotyledonous.	Dicotyledonous.
Thallogenous.	Acrogenous.	Endogenous.	Exogenous.
No Venation.	Forked Venation.	Parallel Venation.	Reticulated Venation.
Cryptogamous. Peculiar reproductive cells.	Cryptogamous. Peculiar reproductive cells.	Stamens and Pistils (Phanerogamous).	
Tubes (thecæ) with Spores, or naked Spores.	Tubes with Spores.	Seeds in Seed-vessel or Naked (Angiospermous or Gymnospermous).	
Flowerless.	Flowerless.	Floral Envelopes Ternary.	Flor. En. Binary, Quaternary, or Quinary.

It is impossible to represent the affinities of plants in a linear series. Different groups touch each other at several different points, and must be considered as alliances connected with certain great centres. We find also that it is by no means easy to fix the limits of groups. There are constantly aberrant orders, genera, and species, which form links between the groups, and occupy a sort of intermediate position. In this, as in all departments of natural science, there are no sudden and abrupt changes, but a gradual transition from one series to another. Hence exact and rigid definitions cannot be carried out. In every natural system there must be a certain latitude given to the characters of the

groups, and allowance must be made for constant anomalies, in so far as man's definitions are concerned.

Having examined the general principles upon which the natural system is founded, we shall now give a sketch of the natural system of De Candolle, which is that usually adopted at the present day :—

CLASS I.—DICOTYLEDONES, EXOGENÆ, in which spiral vessels are present; the stem is exogenous; stomata are present, the venation of the leaves is reticulated; the flowers have stamens and pistils, and the symmetry is quinary and binary (or quaternary); the ovules are either in an ovary or naked; and the embryo is dicotyledonous. In this class there are included four Sub-classes :

Sub-class I.—THALAMIFLORÆ.—Flowers usually with two envelopes (calyx and corolla) (p. 114), petals separate (not coherent), inserted on the end of peduncle (thalamus), and stamens hypogynous. Figs. 278, 279; also fig. 177, p. 132.

Examples.—Crowfoots, water-lilies, poppies, crucifers, violets, chickweeds, mallows, geraniums, and wood-sorrels.

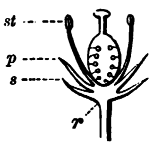


Fig. 278.

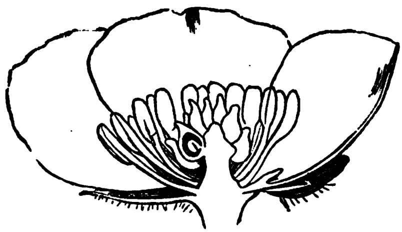


Fig. 279.

Fig. 278.—Diagram to illustrate Thalamifloral Dicotyledons. Sepals *s*, petals *p*, and stamens *st*, all free (not coherent), and inserted into the receptacle *r*, below the ovary (hypogynous).

Fig. 279.—Flower of a Ranunculus, illustrating Thalamifloral *Dicotyledons.* The petals are separately inserted on the thalamus, *and the stamens* are hypogynous.

Sub-class II.—CALYCIFLORÆ.—Flowers usually dichlamydeous, petals either separate or united, stamens either perigynous or epigynous. Figs. 280, 281; also figs. 178, 179, p. 133. This sub-class has two sections—

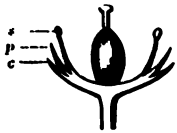


Fig. 280.

Fig. 281.

1. *Polypetalæ*, in which the petals are separate. Fig. 282.
Examples. — Pea-family, rose-family, willow-herbs, saxifrages, umbelliferous plants.

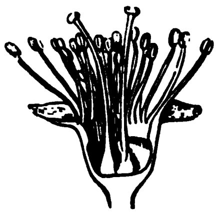


Fig. 282.

Fig. 283.

Fig. 280.—Diagram to illustrate Calycifloral Dicotyledons with perigynous stamens. Petals *p*, and stamens *s*, inserted on the calyx *c*, surrounding the ovary.
Fig. 281.—Diagram to illustrate Calycifloral Dicotyledons with Epigynous stamens. Petals *p*, and stamens *s*, united to the calyx *c*, and all adherent to the ovary *o*, so as to be above it; *r*, receptacle.
Fig. 282.—Flower of Cherry, one of the Rosaceæ, showing a Calycifloral Dicotyledon, with a polypetalous corolla.
Fig. 283.—Flower of Campanula, showing a Calycifloral Dicotyledon, with a gamopetalous corolla.

2. *Gamopetalæ* (*Monopetalæ*), in which the petals are united (coherent). Fig. 283.

Examples.—Madderworts, teazels, valerians, composite plants, harebells.

Sub-class III. — COROLLIFLORÆ. — Flowers dichlamydeous, petals united (coherent), corolla hypogynous, usually bearing the stamens. Fig. 284.

Examples.—Heaths, borage-family, potato-family, figworts, labiate plants, primroses.

Fig. 284.

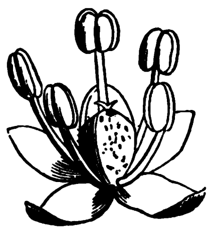


Fig. 285.

Sub-class IV.—MONOCHLAMYDEÆ (no corolla), (p. 114), flowers either with a calyx only or none. Figs. 285, 286. In this sub-class there are two sections—

1. *Angiospermæ*, in which the ovules are contained in a pericarp, and are fertilized by the action of the pollen on the stigma.

Examples.—Dock-family, laurels, spurge-laurels, catkin-bearing trees.

Fig. 284.—Flower of Primrose, showing a Corollifloral Dicotyledon, with the stamens united to the corolla, which is hypogynous.

Fig. 285.—Flower of Goosefoot (Chenopodium), showing a Monochlamydeous or Apetalous Dicotyledon.

2. *Gymnospermæ*, in which the ovules are not contained in a true pericarp, and are fertilised by the direct action of the pollen without the intervention of a stigma, and the embryo has numerous cotyledons. Fig. 287.

Examples.—Cone-bearing trees and cycads.

Fig. 286.

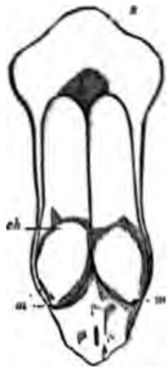


Fig. 287.

CLASS II.—MONOCOTYLEDONES, ENDOGENÆ, in which spiral vessels are present; the stem is endogenous; stomata occur; the venation is usually parallel, sometimes slightly reticulated; the flowers have stamens and pistils, and the symmetry is ternary; the ovules are contained in an ovary; the embryo is monocotyledonous. Under this class are included two sub-classes:

Sub-class I.—PETALOIDEÆ, in which the leaves are parallel-veined; the flowers usually con-

Fig. 286.—Achlamydeous staminate flower of Spurge (Euphorbia). Peduncle *p*, supporting the solitary stamen, constituting a staminate flower. *b*, Bract.

Fig. 287.—Scale of a mature cone of Scotch Fir, with two winged seeds at the base, the opening *m*, and the chalaza *ch*.

sist either of a coloured perianth or of whorled scales. This sub-class is divided into sections :

1. *Epigynæ*, in which the perianth is adherent, the ovary is inferior, and each flower has usually stamens and pistil. Fig. 288.

   Examples. — Orchids, bananas, iris, amaryllis, snow-drop, and snow-flake.

Fig. 288.

Fig. 289.

2. *Hypogynæ*, in which the perianth is free, the ovary is superior, and each flower has usually stamens and pistil. Fig. 289.

Fig. 288.—Monocotyledon, snow-flake (*Leucojum*), with the ovary inferior, and the floral envelopes and stamens above the ovary (epigynous).

Fig. 289.—Flower of a Monocotyledon, the white lily (*Lilium album*)—floral envelopes below the ovary (hypogynous).

Examples.—Lily, meadow-saffron, rushes, and palms.

3. *Incompletæ*, flowers incomplete, often staminate and pistillate (pp. 114, 115), with no proper perianth, or with a few verticillate scales. Fig. 290.

Examples.—Arums and screw-pines.

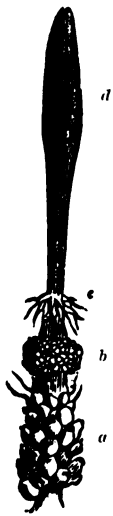


Fig. 290.

Fig. 291.

Sub-class II.—Glumiferæ, flowers glumaceous, consisting of imbricated bracts, venation parallel. Fig. 291.

Examples.—Sedges and grasses.

Fig. 290.—One of the incomplete Monocotyledons. A species of Arum, in which the staminate and pistillate flowers are separate, and are each surrounded by minute scales; *a*, pistillate flowers; *b*, staminate flowers; *c*, abortive flowers; *d*, end of spadix.

Fig. 291.—Glumiferous Monocotyledon, Wheat (*Triticum*), consisting of numerous flowers formed by imbricated bracts. (For description of the woodcut see p. 136.)

Class III.—ACOTYLEDONES, in which the plants are either entirely cellular, or consist partly of scalariform vessels; the stem, when woody, is acrogenous; stomata occur in the higher orders; the leaves are either veinless or have a forked venation; no flowers are present; the reproductive organs consist of antheridia and archegonia; spores or cellular embryos are produced, which have no cotyledons. Under this class there are two divisions:—

Fig. 292.

Sub-class I.—Acrogenæ, with a distinct stem, bearing leaves and branches. Fig. 292.

Examples.—Ferns, club-mosses, horse-tails, and mosses.

Sub-class II.—Thallogenæ, having no distinct stem or leaves, but forming a cellular expansion of various kinds, which bears the organs of reproduction. Fig. 262, p. 183.

Examples.—Lichens, sea-weeds, and fungi.

Fig. 292.—An Acrogen or Acotyledon, Royal Fern (*Osmunda regalis*), with an axis and leaves. The upper part of the frond, *f*, bears the fructification, *s*, in the form of sporangia and spores.

QUESTIONS.

1. What is meant by the natural system of classification? Explain its principles.
2. Give a natural division of plants founded on their tissues.
3. Give a natural division of plants founded on the embryo.
4. Give a natural division of plants founded on the stem.
5. Give a natural division of plants founded on the venation of their leaves.
6. Give a natural division of plants founded on their organs of reproduction.
7. Divide flowering plants according to the number of parts in each floral series.
8. Mention the three great classes of the natural system.
9. Give the characters of each of these classes.
10. Give an example of each of these classes.
11. What are the sub-classes of dicotyledonous plants?
12. Define each of these sub-classes.
13. What are the sections of calycifloral plants? Define them.
14. Give the sections of monochlamydeous plants. Define them.
15. Give the sub-classes of monocotyledonous plants.
16. Define these sub-classes.
17. What are the sections of the petaloid monocotyledons? Give their characters.
18. What are the sub-classes of acotyledonous plants?
19. Give the characters of these sub-classes.

When farther advanced the pupil should be asked to give examples of the orders in each of the classes and sub-classes.

CHAPTER III.

CHARACTERS OF THE CLASSES, SUB-CLASSES, AND OF SOME OF THE ORDERS OF THE NATURAL SYSTEM.

In this chapter it is proposed to give the characters of the classes and sub-classes of the vegetable kingdom according to the natural system, and to illustrate them by a few of the more important orders represented in the British flora. By this means the pupil will learn the method which must be followed in referring plants to their places. The Linnæan system may be used as an index or key to the natural method. This plan is adopted in Babington's *Manual of British Plants*, and in Hooker and Arnott's *British Flora*. These books, as well as Hooker's *Student's Flora* and Bentham's *Handbook*, may be used in determining the names of the indigenous plants of Britain. In the present work we shall only explain the principles of classification, and give examples of the method to be pursued in ascertaining the names of genera and species. Those who desire to enter into the subject more fully are referred to Balfour's *Manual of Botany*.

DIVISION A.—Phanerogamous (Flowering) Plants.

CLASS I.—DICOTYLEDONES OR EXOGENÆ.

This is the largest Class in the vegetable kingdom. The plants included in it have a cellular and vascular system, the latter consisting partly of elastic spiral ves-

sels (fig. 11, p. 5). The stem is more or less conical, and exhibits wood and true bark. The wood is exogenous—*i.e.* increases by additions at the periphery, the oldest and hardest part being internal (p. 27); it is arranged in concentric circles. Pith exists in the centre, and from it diverge medullary rays (fig. 46, p. 27). The bark is separable, and increases by additions on the inner surface. The epidermis is furnished with stomata (fig. 77, p. 52). The leaves are reticulated (fig. 70, p. 48), and usually articulated to the stem. The flowers are formed upon a binary or quinary type, and have stamens and pistils (pp. 109, 111). The ovules are either enclosed in an ovary (fig. 199, p. 144), and fertilized by the application of the pollen to the stigma, or they are naked (fig. 287), and fertilized by the direct action of the pollen. The embryo has two or more opposite cotyledons (fig. 20, p. 13).

SUB-CLASS 1.—THALAMIFLORÆ.

Polypetalous Hypogynous Dicotyledons.

Calyx and corolla present; petals distinct, inserted into the receptacle (thalamus); stamens hypogynous (p. 132). The name Thalamifloræ is derived from the circumstance that the different whorls of the flower (calyx, corolla, stamens, and pistil) are inserted separately on the part called the thalamus, which is situated at the upper end of the flowerstalk (fig. 177, p. 132).

Various methods may be followed in the arrangement of the orders under the sub-classes. We commence with the Ranunculus order, because in it all the

parts of the flower—sepals, petals, stamens, and carpels—are distinct and separate. It would be impossible, in the narrow limits of an elementary work, to give descriptions of all the orders of plants. We shall take some of the common British plants, and by means of them point out the characters of a few of the more important natural orders under which they have been placed.

Order RANUNCULACEÆ, the Crowfoot Family (fig. 294).

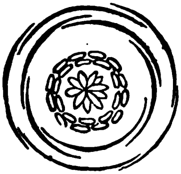


Fig. 294.


Fig. 295.

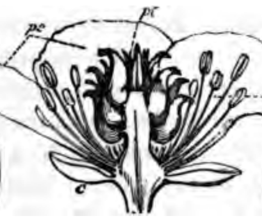


Fig. 293.


Fig. 296.

Sepals 3-6, frequently 5, deciduous (fig. 293 *c*). Petals 5-15 (fig. 293 *pe*), rarely abortive, sometimes anomalous in form (figs. 169, 170, p. 123), occasionally with scales at the base. Stamens usually indefinite, hypogynous (fig. 293 *e*); anthers firmly adhering to their

Fig. 293 to 299 exhibit the organs of reproduction of *Ranunculus acris*, to illustrate the natural order Ranunculaceæ.

Fig. 293.—Flower cut vertically. *c*, Calyx. *pe*, Petals. *e*, Stamens. *pi*, Pistil composed of several carpels on an elongated receptacle or axis.

Fig. 294.—Diagram of the flower, showing five imbricated sepals, five petals alternating with the sepals, indefinite stamens in several whorls, and numerous carpels or achenes in the centre.

Fig. 295.—Adnate anther seen on the outer side. The anther is in this instance extrorse. In the pæony it is introrse.

Fig. 296.—Adnate anther viewed on the inside.

stalk (figs. 295, 296); carpels numerous, one-celled (fig. 293 p), usually distinct; ovary containing one inverted ovule (fig. 297 g), or several united to the inner edge. Fruit various, either achenes (fig. 298) or follicles (fig. 221, p. 156), sometimes succulent. Seeds with hard albumen, erect or pendulous; embryo small (fig. 298 e). Herbaceous, rarely shrubby plants, having simple, often much divided leaves, with sheathing stalks.

Fig. 297.

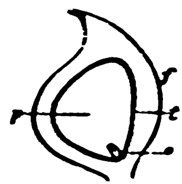


Fig. 298.

Juice watery. The plants of the order are found in cold, damp climates, and in the elevated regions of warm countries. The order has narcotico-acrid properties, and the plants are usually more or less poisonous. The acridity is frequently volatile. It varies in different parts of the plants, and at different seasons.

To illustrate the order, take the common buttercup, which belongs to the genus Ranunculus, and dissect it carefully. There are three species of Ranunculus, called in common language buttercups :—(1.) *Ranunculus bulbosus*, bulbous crowfoot, having its sepals reflexed, flower-

Fig. 297.—Vertical section of the ovary *o*, showing the erect ovule *g*. *s*, Stigma.

Fig. 298.—Fruit or achene cut vertically. *f*, Pericarp. *t*, Spermoderm or integument of the inverted seed. *p*, Perisperm or albumen, between fleshy and horny. *e*, Minute embryo.

stalks furrowed, and root bulbous ; (2.) *Ranunculus repens*, creeping crowfoot, which has a stem with runners, its flowerstalks furrowed, its sepals not turned back, and its root not bulbous ; (3.) *Ranunculus acris*, upright meadow-crowfoot, which has its flowerstalks rounded (not furrowed), its sepals not turned back, and its root not bulbous.

Fig. 299.

Take the bulbous crowfoot, as shown in fig. 299. First there is seen the bulb, at the base, from whence the roots are given off. This bulb must be regarded as a short thickened stem. From it the leaves proceed upwards and the roots downwards. There is a cluster of radical leaves ; each of these is cut into

three stalked leaflets, which are again divided into three lobes. Then, on the flowerstalks, *a′ a″ a‴*, are also seen cut leaves with narrower divisions. The peduncle, *a′*, ends in a flower, *f′*, which terminates the first axis; the flower, *f″*, terminates the second axis, *a″*; and the flower, *f‴*, terminates the third axis, *a‴*. The peduncle below the flower is furrowed. The flower consists of calyx, corolla, stamens, and pistil. The five sepals of the calyx are turned down (reflexed), the five yellow petals have a pore at the base covered by a scale; the stamens are hypogynous, very numerous (twenty or more, indefinite), and consist of filaments and anthers which open on the side farthest from the pistil (extrorse). The pistil consists of numerous green carpels (fig. 297), each containing one ovule. These carpels, when ripe, form single-seeded seed-vessels (achenes), which do not burst, but fall to the ground entire. On making a section of the achene, the single erect seed is observed (fig. 298), containing a small embryo and a quantity of white nourishing matter (albumen or perisperm). Some species of Ranunculus are distinguished by the leaves not being divided.

The Marsh Marigold (*Caltha*) is like a Ranunculus, but it has no corolla (only a calyx with yellow sepals), and the fruit consists of seed-vessels (follicles) which contain several seeds, and open on the side next the centre of the flower. The mode in which the sepals are arranged in the bud is the means of distinguishing Clematis from Anemone. In the former the æstivation (p. 119) of the calyx is valvate or induplicate, in the latter imbricate. In both these genera there is no corolla.

In some plants — such as monkshood, larkspur, columbine, and hellebore—the sepals or petals, or both, are peculiar, and occur in the form of hollow tubes or spurs (figs. 169, 170, p. 123).

The next Thalamifloral orders we shall take are also well represented in Britain. They have the parts of the calyx and corolla, as well as the stamens, separate, but the carpels united together.

Order Nymphæaceæ, the Water-lily Family. Aquatic plants with submersed rhizome, large showy

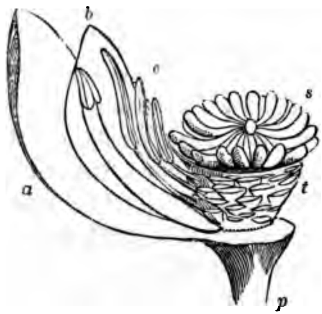


Fig. 300.

flowers, numerous petals and stamens, which are placed on a fleshy disk enclosing the ovary (fig. 300). *Victoria regia* belongs to the order. It is one of the largest aquatic plants. *Nymphæa Lotus* is supposed by some to be the lily of the Old Testament.

Fig. 300.—Section of a flower of the white Water-lily (*Nymphæa alba*), showing the pistils, and the receptacle or torus bearing the stamens and petals. *p*, Peduncle or flower-stalk. *t*, Elevated torus or receptacle. *s*, Radiating stigmas. *a*, Sepal. *b*, Petal. *c*, Stamens.

Order PAPAVERACEÆ, the Poppy Family. This order is distinguished by its 2 sepals (fig. 301), which fall off very early (caducous), 4 petals (fig. 302), numerous stamens (fig. 303), capsular fruit opening in the poppy by

Fig. 301.

Fig. 302.

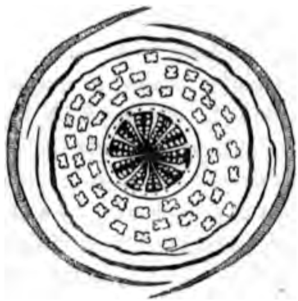


Fig. 303.

pores below the united stigmas (fig. 229, p. 158), fruit sometimes resembling a siliqua (fig. 302), and thus showing an alliance with Cruciferæ. The plants are in general poisonous. *Papaver somniferum* has a milky

Fig. 301.—Two caducous sepals of the Poppy, covering the corolla.

Fig. 302.—Four petals of Celandine, numerous stamens, and a pod-like capsule.

Fig. 303.—Diagram showing 2 sepals, 4 crumpled petals, numerous stamens, pistil with parietal placentas, in the Poppy.

juice, which, when the capsule is cut, exudes, and constitutes opium. Some of the plants (as the celandine fig. 302) have an orange juice, others, as blood-root, have a red juice. In the common poppy the stigmas are sessile and radiating; while in the Welsh poppy (*Meconopsis*) the stigma is supported on a style.

Order CRUCIFERÆ, the Wallflower and Cress Family (fig. 304).—Sepals 4, deciduous. Petals 4, hypogynous, alternating with the sepals, deciduous, cruciate (fig. 313 *a*, p. 241). Stamens 6, tetradynamous (figs. 306, 307), two short solitary (fig. 307 *e'*), four longer (fig. 307 *e''*) in 2 pairs. Green glands between the petals and stamens and ovary (fig. 307 *g*). Ovary superior, with parietal placentas, which meet in the middle, forming a spurious dissepiment (replum) (fig. 308 *c*); stigmas 2 (306 *s*). Fruit a siliqua (figs. 309, 310), or a silicula (fig. 223, p. 157), opening by two valves, which separate from the replum. Seeds attached in a single row by a short stalk to each side of the placentas (fig. 205, p. 146); no albumen; embryo with the radicle folded upon the cotyledons (fig. 231, p. 163). —Herbaceous plants, with alternate leaves, and yellow or white, rarely purple, flowers, without bracts. This order is well distinguished by its tetradynamous stamens and its fruit. Most of the plants belonging to this order are European.

The order has been subdivided into sections, according to the mode in which the radicle of the embryo is folded on the cotyledons, as well as according to the nature of the fruit. The distinctive characters taken from the embryo are minute, but they can

be seen in the ripe seed on removing the outer covering.

Fig. 305.

Fig. 304. Fig. 306.

Fig. 304.—Inflorescence of a cruciferous plant, a kind of mustard (*Sinapis orientalis*). In the young state the flowers are corymbose, while in the advanced state they become racemose. The fruit-pods (*siliquæ*) are supported on nearly equal pedicels, while the lowest flowers, in their partially-expanded state, have the longest pedicels, and thus form a corymb. The plant shows the transition from a corymb to a raceme.

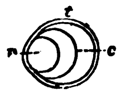
Figs. 305-312.—Organs of fructification of *Erysimum lanceolatum*, one of the Cruciferæ.

Fig. 305.—Diagram of the flower, showing the arrangement of four sepals, four petals alternating with them, six tetradynamous stamens, and a siliqua with replum.

Fig. 306.—Vertical section of the flower. *c*, Calyx. *p*, Petals. *e*, Stamens. *o*, Ovary laid open. *s*, Stigma.

As the embryo occupies the whole of the interior of the seed, it appears at once when the coat of the seed is taken off. Thus, take the entire ripe seed of mustard as sold in the shops, and after soaking it in warm water, re-

Fig. 308.



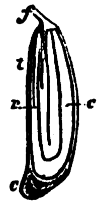


Fig. 307. Fig. 309. Fig 310. Fig. 312. Fig. 311.

move the outer covering, and the little embryo will fall out. By the naked eye, or by means of a lens, the cotyledons may be seen folded on the small root (radicle). The radicle in other cases lies on the edge of the cotyledons, which are not folded (fig. 311), while at times it lies on the back of the cotyledons (fig. 312).

Fig. 307.—Flower deprived of its envelopes. *c c*, Scars left by the fall of the sepals. *g*, Glands which are situated at the base of the stamens. *é*, Two short stamens. *e''*, Four long stamens in two pairs. *p*, Pistil.

Fig. 308.—Horizontal section of the ovary. *g*, Ovules. *c*, Spurious dissepiment (replum) which divides the ovary into two cavities. This replum is formed by the placentas.

Fig. 309.—Siliqua or long pod. The valves separate from below upwards.

Fig. 310.—Siliqua with one of its valves removed, in order to show the seeds attached to the sides of the replum.

Fig. 311.—Vertical section of the seed. *f*, Small stalk. *t*, Covering of seed swollen at the nourishing point, *e*. *r*, Radicle. *c*, Cotyledons.

Fig. 312.—Horizontal section of the seed. *t*, Covering of seed. *r*, *Radicle.* *c*, Cotyledons with radicle on their back.

As regards the fruit, there are marked differences in cruciferous plants. The pod may be long and narrow (a siliqua), with two valves opening lengthwise, when the fruit is ripe, as in wallflower (fig. 205, p. 146); or it may be short (a silicula), with the partition in its broadest diameter, with flat or convex valves, as in whitlow-grass (fig. 223, p. 157); or it may be a short pod, with the partition in its narrow diameter, on account of the valves being each folded, as in shepherd's purse; or it may be a pod divided by transverse partitions, each division containing one seed, as in the radish; and at times the pod is short and contains only one seed, as in woad. In books describing British plants you will find Cruciferæ systematically arranged according to these characters.

There are no poisonous plants in the order. Many of the most common culinary vegetables belong to it, such as cabbage, cauliflower, turnip, radish, cress, horse-radish, etc. They contain much sulphur and nitrogen, and, on this account, when decaying, give off a disagreeable odour. Kerguelen Land cabbage (*Pringlea antiscorbutica*) belongs to the order. Many garden flowers, such as wallflower, stock, rocket, and honesty, are found in this order.

Many common weeds serve as illustrations. Let us take the common wallflower (*Cheiranthus Cheiri*). It is a somewhat shrubby plant, growing often on rocks and walls. The leaves are narrow and tapering to each end (lanceolate), not divided, and covered with closely-appressed hairs, which, when examined by the lens, are found to be forked (fig. 81, p. 54). The flowers are on

stalks, and their inflorescence is a raceme (p. 103), or a corymb (p. 104). The sepals are 4, erect, and 2 of them are enlarged at the base. The petals are usually yellow, 4, arranged crosswise, with the lower part (claw) narrow. There are 4 long and 2 short stamens, which are hypogynous. The fruit is a siliqua (fig. 205, p. 146), with a short style surmounted by a stigma, which has 2 spreading lobes. The radicle of the embryo lies at the edges of the 2 cotyledons, marked thus o =, where o is the radicle, and = the cotyledons.

The common stock (*Matthiola*) differs from the wallflower chiefly in having the lobes of the stigma not spreading, and either thickened at the back, or with a horn at the base.

The common mustard of the fields (*Sinapis arvensis*) is another cruciferous plant, with a siliqua which can be easily examined; so also white mustard (*Sinapis alba*), as seen in fig. 313. The cruciform flower *a*, the long hairy pod or siliqua with its sword-like beak *b*, and the seed *c*, are delineated. There is also a figure of *Sinapis orientalis* (fig. 304).

To illustrate the division with short pods and a broad replum, take the common scurvy-grass of the seashore (*Cochlearia officinalis*). In this plant the radical leaves are somewhat kidney-shaped and stalked, while those of the stem are oblong and have no stalks. The flowers are white. The pod is oval or globular; its valves very convex, with a prominent rib in the middle; the seeds are numerous. The plant called honesty in gardens shows this division well. In the shepherd's-purse (*Cápsella Bursa-pastoris*) you have an example of

the division in which the plants have short pods and a narrow replum. The radical leaves—*i.e.* the leaves at the base—are often pinnatifid (p. 64), the upper

Fig. 313.

ones embracing the stem ; the leaves are very varied in their form. The flowers are small and white. The fruit is a triangular silicula, with a heart-like division at its apex (obcordate). The valves are boat-shaped,

Fig. 313.—White mustard plant (*Sinapis alba*), with cruciform calyx and corolla *a*, hairy siliquas *b*, and seed *c*.

and not winged as in penny-cress (*Thlaspi*). The seeds are many and attached to the narrow replum. The jointed charlock or wild radish of the corn-fields (*Raphanus Raphanistrum*) shows a peculiar jointed or beaded siliqua, each of the joints containing one seed.

We next take a family in which there are marked irregularities in the flower, and a cohesion of the stamens, which at once separate it from those already illustrated.

Order Violaceæ, the Violet Family. Sepals 5, persistent, usually elongated at the base. Petals 5, unequal, lower one spurred (fig. 315). Stamens 5; anthers 2-celled, cohering, with a prolongation at the top and two projecting processes below (fig. 316). Ovary unilocular; style single, slightly curved, with an oblique hooded stigma (fig. 316, *s*). Fruit a 3-valved capsule, opening by three valves, placentas on the middle of the valves (fig. 317). Seeds numerous; embryo straight in the axis of fleshy albumen (fig. 318).—Herbs or shrubs, with alternate, rarely opposite, leaves, having persistent stipules (fig. 115, p. 69). They are natives of Europe, Asia, and America.

To illustrate this order, take the common wild pansy (*Viola tricolor*, fig. 314). This species is the origin of all the cultivated varieties of pansy. The stem is angled and branched, and bears oblong crenate (p. 65) leaves; the stipules are pinnatifid, with a large lobe at the end (fig. 115, p. 69); the sepals are 5, and they are prolonged at the base so as to project downwards; the corolla consists of 5 petals of different sizes, the lower one *having* a hollow spur; the stamens are 5, united by

their anthers, and two of the lobes send long processes into the hollow spur of the corolla. The upper

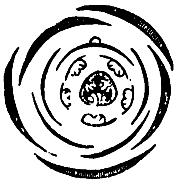


Fig. 314.

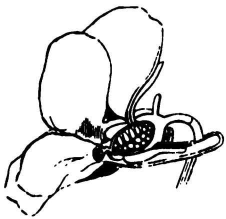


Fig. 315.

Fig. 316.

Fig. 317.

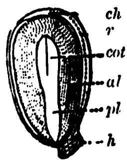


Fig. 318.

petals are purple, the lateral bluish, and the lower one yellow, hence the name tricolor (three-coloured). There

Figs. 314 to 318 illustrate the natural order Violaceæ.

Fig. 314.—Diagram of the flower of the Pansy, having five sepals, five petals, five stamens with appendages, a three-valved fruit with parietal placentas.

Fig. 315.—Section of the flower of a Violet, showing the spurred petal, with a staminal appendage within it, and the ovary with numerous ovules.

Fig. 316.—Five stamens of a Violet united by their anthers, two of them with long filiform appendages, *a*; obliquely hooded stigma in the centre, *s*.

Fig. 317.—Fruit of the Pansy opening in a loculicidal manner by three valves. Seeds numerous in the middle of the valves.

Fig. 318.—Anatropal seed of the Pansy cut vertically, showing the straight embryo, *pl*, with the cotyledons, *cot*, in the midst of albumen, *al*. The hilum is marked *h*, the chalaza *ch*, and the raphe *r*.

are several other species of British violet, such as the dog-violet, the wood-violet, the hairy violet, the marsh violet, and the sweet violet. They are distinguished by their leaves, stipules, peduncles, and antherine spurs.

The next thalamifloral family to which we call attention, is one which contains many common weeds found in the garden, the fields and woods, as well as by river-banks and road-sides.

Order CARYOPHYLLACEÆ, the Carnation and Chick-weed Family.—Sepals 4-5 (fig. 319), separate, or united in a tube (figs. 320 *c*, 329 *c*), persistent—*i.e.* remaining after the flower withers. Petals 4-5 (fig. 329 *p*), with a claw often bifid or bipartite. Stamens (fig. 320 *e*) usually double the number of the petals. Ovary single, often stalked (fig. 320 *g*), composed of 2 to 5 carpels (fig. 321), which are usually united by their edges; stigmas 2-5 (fig. 320 *s*). Capsule unilocular (figs. 327, 322, 2) 2-5-valved, opening either by valves, or more commonly by twice as many teeth as stigmas (figs. 322, 324, 326); placenta in the axis of the fruit (fig. 322, 2, *p*). Seeds numerous, with mealy albumen, and the embryo surrounding it (fig. 323).—Herbs, with opposite, entire, exstipulate leaves, and definite inflorescence (figs. 325, 326; and 145, p. 106). They inhabit chiefly temperate and cold regions. The order has been divided into two sub-orders—viz. 1. *Alsineæ*, sepals distinct (fig. 325); 2. *Sileneæ*, sepals cohering (fig. 329).

The plants of the order are usually insipid. The greater part of them are weeds, but some are showy garden flowers. To the latter belong the varieties of

carnation or clove-pink, picotees, bizarres and flakes, and numerous species of pink and campion.

The order Caryophyllaceæ may be illustrated by

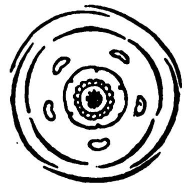


Fig. 319.

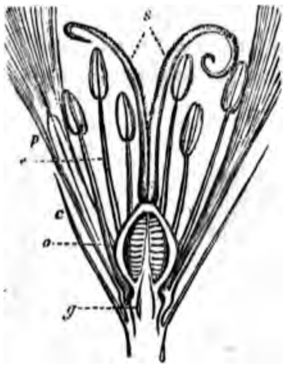


Fig. 320.

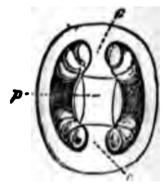


Fig. 321.

many common British plants. In the sub-order Alsineæ we meet with the common narrow-leaved mouse-ear chickweed (*Cerastium triviale*). The stem is

Figs. 319 to 324. Illustrations of the natural order Caryophyllaceæ.

Fig. 319.—Diagram of the flower of *Stellaria media*, common Chickweed, belonging to the natural order Caryophyllaceæ, sub-order Alsineæ. The flower consists of five imbricate sepals, five alternate petals, five stamens, a unilocular ovary, with a free central placenta, and numerous ovules.

Fig. 320.—Section of the flower of *Dianthus Caryophyllus*, Carnation, belonging to sub-order Sileneæ. *c*, Gamosepalous calyx; *p*, petals, cohering with the stamens at the base; *e*, stamens; *g*, gynophore or thecaphore—*i.e.* the stalk supporting the ovary; *o*, ovary with central placenta and ovules; *s*, two stigmas, which have papillæ all along their inner surface.

Fig. 321.—Horizontal section of the ovary in a very young state, showing the partitions *c c*, which divide the ovary into two cavities. These divisions ultimately disappear, leaving the placenta, *p*, bearing the ovules, free in the centre.

hairy and viscid, and bears leaves somewhat lanceolate in form. The inflorescence is a definite corymb or dichasium—the central flower expanding first, and each axis dividing into two. The calyx consists of 5 sepals, which are as long as the small flower-stalk and the corolla, but only about half the length of the curved fruit. Petals are 5, cloven; stamens 10, inserted below the

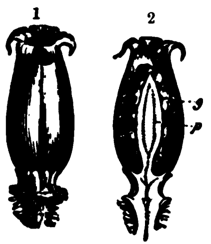


Fig. 322.

Fig. 323.

Fig. 324.

ovary; pistil composed of 5 coherent carpels, with 5 styles. Fruit opening at the top by 10 teeth. The mode of inflorescence is seen in figs. 325, 326, which show the flower-stalk and flower of two other species of Cerastium; and the seed-vessels are seen in figs. 327, 328.

Another plant common in woods, which illustrates

Fig. 322.—Capsule of *Lychnis Githago* at the period of dehiscence, when the pericarp separates into five valves or teeth at the summit. 1, The capsule entire. 2, Capsule cut vertically, to show the seeds, *g*, grouped in a mass, on a free central placenta, *p*.

Fig. 323.—Seeds. 1, Entire seed. 2, Seed cut vertically. *t*, Spermoderm, or covering of the seed. *c*, Peripherical embryo, surrounding the mealy albumen, *p*.

Fig. 324.—Capsule or dry seed-vessel of *Cerastium triviale*, after dehiscence. *c*, Persistent calyx. *p*, Pericarp dividing at the apex, *v*, into ten teeth, which indicate the summits of as many *valves united* below.

this division of the Caryophyllaceæ, is the greater stitchwort (*Stellaria Holostea*). It has a nearly erect stem, with sharp and rough angles, and bears lanceolate leaves drawn out into a point, placed opposite to each other. The flowers are large and white; calyx of 5 sepals;

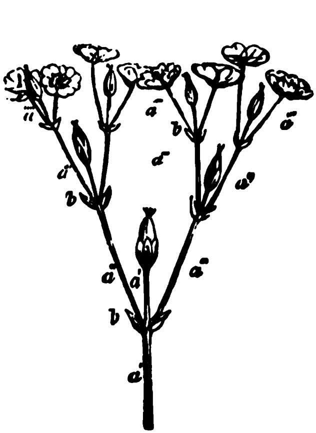


Fig. 325.

Fig. 326.

corolla of 5 deeply-cleft petals, which are twice as long as the sepals; stamens 10; pistil with 3 styles, and capsule opening with 6 teeth. The common chickweed (*Stellaria media*) is distinguished by its ovate or egg-shaped leaves.

Fig. 325.—Inflorescence of *Cerastium grandiflorum*. *b b b*, Opposite bracts produced at each of the branchings. The letters, *a* accented, mark the primary, secondary, tertiary, and quaternary axes. The primary axis, a', ends in a flower which has passed into fruit. Inflorescence determinate. Evolution of flowers centrifugal.

Fig. 326.—Inflorescence of *Cerastium tetrandrum*. Letters have the same meaning as in the last figure. In the quaternary axis, a'''', the inflorescence becomes lateral by the non-development of the flower-buds on one side. The inflorescence is dichasial.

In the sub-order Sileneæ, the plant most easily examined is the common red campion (*Lychnis dioica*). In this case we meet with staminate flowers on one plant and pistillate flowers on another plant. The plant is therefore called diœcious. It has a stem 1-2 feet high, bearing ovate acute leaves. Inflorescence, definite, dichasial. Sepals 5, united. Petals 5, pink-coloured, cleft, and with a crown—*i.e.* scales near the upper part

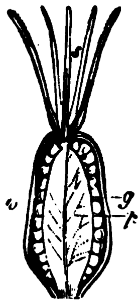


Fig. 327.

Fig. 328.

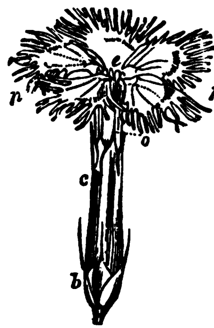


Fig. 329.

of the petals. Styles in the pistillate flower, 5. Capsule opening by 10 recurved teeth (fig. 224, p. 157). Placenta in the axis covered by numerous seeds (figs. 327, 328). The common pink (*Dianthus*) is distinguished by its 2 styles, seed-vessel opening by 4 teeth,

Fig. 327.—Pistil of *Cerastium hirsutum* cut vertically. *o*, Unilocular or one-celled ovary. *p*, Free central placenta. *g*, Ovules. *s*, Styles.

Fig. 328.—The same cut horizontally, and the halves separated so as to show the interior of the cavity of the ovary, *o*, with the free central placenta, *p*, covered with ovules, *g*,

Fig. 329.—Polypetalous flower of *Dianthus monspessulanus*. *b*, Scales at base of calyx. *c*, Calyx. *p p*, Petals with their claws, *o*, approximated.

and scales at the base of the calyx. These characters are shown in the carnation (figs. 329; 137, p. 100). The catchfly (*Silene*) has 3 styles and 6 teeth in its seed-vessel.

We now pass to two orders which call for attention on account of the cohesion of the filaments of the stamens by which the plants become monadelphous. The orders are the mallow and the geranium families.

Order MALVACEÆ, the Mallow Family. Sepals 5 (fig. 330), more or less cohering at the base (fig. 332 *c*),

Fig. 330.

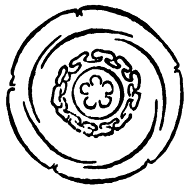


Fig. 331.

with a valvate æstivation, often bearing an external calyx (*epicalyx*) (fig. 332 *i*). Petals equal in number to the sepals; twisted in the bud. Stamens numerous (fig. 332 *a*), filaments monadelphous (figs. 332 *t*; 181, p. 134); anthers 1-celled (fig. 333), kidney-shaped, opening round the upper margin. Ovary formed by

Figs. 330-342.—Organs of reproduction of *Malva sylvestris*, to illustrate the natural order Malvaceæ.

Fig. 330.—Flower showing five petals, monadelphous stamens, peduncle or flowerstalk, and two stipules, *s* (leaf being removed).

Fig. 331.—Diagram of the flower, showing the different whorls or verticils; five valvate or induplicate sepals, five twisted petals, indefinite monadelphous stamens, and united carpels.

the union of several carpels round a common axis (figs. 334, 339 *o*), either distinct or cohering; styles as many as the carpels (figs. 332, 339 *s*), united or free. Fruit capsular; carpels one or many-seeded, sometimes closely united, at other times separate or separable (figs. 334, 335); embryo curved (fig. 336); cotyledons twisted


Fig. 333.

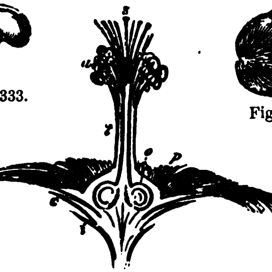


Fig. 332.


Fig. 335.

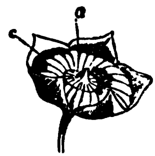


Fig. 334.


Fig. 336.


Fig. 337.

(fig. 338).—Herbaceous plants, trees or shrubs, with alternate stipulate leaves (fig. 340 *s*), more or less divided, and often with stellate hairs (fig. 82 *b*, p. 54). They are found chiefly in tropical countries, and in the warm temperate zone. The plants of the order are wholesome, and yield mucilage. Some furnish materials for cordage, others supply cotton.

Fig. 332.—Vertical section of the flower. *i*, Epicalyx, or involucre; *c*, calyx; *p*, petals; *t*, tube of monadelphous stamens, forming an arch above the ovary, *o*, and united at the base to the petals; *a*, anthers at the summit of the filaments, free; *s*, styles free at the summit, united below.

Fig. 333.—Reniform one-celled anther, opening along the edge, separated with the upper part of the filament.

Fig. 334.—Fruit, surrounded by the persistent calyx, *c*, consisting of whorled carpels united together by the axis, *a*.

Fig. 335.—A separate carpel viewed laterally.

Fig. 336.—Curved embryo. Fig. 337.—Exalbuminous seed.

The mallow order is illustrated by the common mallow (*Malva sylvestris*). The stem of the plant is from 2 to 3 feet high, and is branched, bearing kidney-shaped leaves which have from 5 to 7 deep lobes and hairy stalks with stipules (fig. 340 *s*). The flowers come off three and four together (fig. 340). The flower-stalks

Fig. 338.

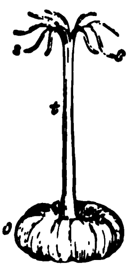


Fig. 339.

Fig. 340.

are hairy. The outer calyx is composed of three leaves. The calyx is divided into 5 segments (5-cleft) (fig. 334 *c*). The corolla is large and purple, and consists of 5 obcordate petals (fig. 340 *p*), which are twisted before they expand. The stamens are numerous, united by their filaments (monadelphous) (fig. 332). The an-

Fig. 338.—Section of the embryo, to show the doubled cotyledons of the Mallow family.

Fig. 339.—Pistil of *Malva Alcea*. *o*, Nine ovaries, united so as to form one. *t*, Column formed by nine styles united to near their summit, where they diverge and separate. Each of the divisions of the style is terminated by a stigma, *s*.

Fig. 340.—Cymose axillary cluster of flowers (fascicle) of *Malva sylvestris*, common mallow.

thers are kidney-shaped and 1-celled, opening round the margin (fig. 333). The pistil consists of many one-seeded carpels arranged in a circle round the axis (fig. 334). The fruit is wrinkled in a net-like manner. Other species are the round-leaved mallow and the musk-mallow. The marsh-mallow (*Althæa*) is distinguished by its outer calyx being 6-9 cleft; while the tree-mallow (*Lavatera*) is separated by having a 3-lobed outer calyx.

Order Geraniaceæ, the Cranesbill Family. Sepals 5, persistent (figs. 342, 343 *c c*). Petals 5, with twisted æstivation (figs. 341, 343 *p p*). Stamens (fig. 343 *e e*) monadelphous, twice or thrice as many as the petals. Ovary of 5 carpels, placed round an elongated axis, a beak-like process (hence the name cranesbill) (fig. 344 *a a*); styles 5, cohering round the axis. Fruit formed of 5 one-seeded seed-vessels, terminated each by an indurated style, which curls upwards, carrying the case with it (fig. 342). Seeds exalbuminous, solitary, with a curved folded embryo, and plaited cotyledons.—Herbs or shrubs with simple, stipulate leaves, which are either opposite, or alternate with peduncles opposite to them. They are distributed over various parts of the world. The species of pelargonium abound at the Cape of Good Hope. The name cranesbill is derived from the long beak-like prolongation of the axis, or what is called the carpophore (fig. 342). Pelargonium is distinguished from geranium by irregular petals, and a thickened prolongation from the upper sepal along the flower-stalk. The species of pelargonium are re-

markable for the beauty of their flowers; and by the art of the gardener many fine varieties have been produced.

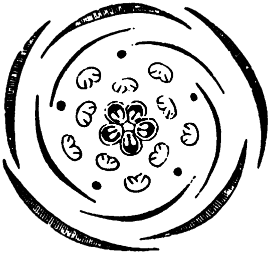


Fig. 341.

Fig. 342.

Fig. 343.

There are twelve species of British geranium. They have peduncles bearing two flowers, with the exception

Figs. 341 to 344 illustrate the natural order Geraniaceæ.

Fig. 341.—Diagram of the flower of a Geranium, with five imbricate sepals, five twisted petals, ten perfect stamens in two rows, and an outer row of abortive stamens, five bi-ovular carpels forming the ovary.

Fig. 342.—Fruit of a Geranium, showing the five one-seeded (monospermal) ripe carpels separating from the base of the long beak-like process, and curving up by means of the styles, which remain adherent to the upper part of the beak.

Fig. 343.—Young flower of *Geranium striatum*, exhibiting the calyx, *c c*, the stamens, *e e*, at first longer than the petals, *p p*.

of the bloody cranesbill (*Geranium sanguineum*), which has one-flowered peduncles. Some of them are annual,

Fig. 344.

some perennial. Those with a perennial root-stock may be illustrated by the wood-cranesbill (*Geranium*

Fig. 344.—Branch of a species of Cranesbill (*Geranium robertianum*), showing at *a a* the beak-like process projecting beyond the flower, to which the carpels are attached.

sylvaticum). It has an erect stem 1 to 3 feet high. Its leaves have 5 to 7 deep lobes, which are cut and serrate. Its flowers are produced in a corymbose manner. Calyx has 5 awned sepals. Corolla has 5 large purple petals, which are obovate and slightly notched, and the claws of the petals are bearded. Stamens are 10, united by their filaments. Its 5 styles are united round the central axis or beak, and when the fruit is ripe, the 5 carpels which surround the base of the beak separate from each other, and are raised up by the recurved styles (fig. 342), and open on their inner side so as to scatter the seeds. Among the species which are annual, may be noticed stinking cranesbill or herb-Robert (*Geranium robertianum*), (fig. 344), very common in woods, and having a disagreeable smell. Its stem is spreading, red, and brittle. Its leaves are divided into 2, 3, or 5 leaflets, which are again cut into segments. Its calyx is hairy. Claw of the petal smooth, and carpels transversely wrinkled, with seeds not dotted.

The genus Erodium (*Storksbill*) is distinguished by having hairs on the inside of its recurved styles, while geranium has none.

We may here notice two natural orders which are nearly allied to Geraniaceæ.

Order Oxalidaceæ, the Wood-sorrel Family. The plants of this order have usually compound ternate leaves (fig. 108, p. 66), 5 sepals, 5 petals with twisted æstivation, 10 stamens in two rows, slightly monadelphous, 5 styles, a capsular, 5-celled fruit, and seeds with an elastic covering. The formula of the order is :

$S_5\, P_5\, \widehat{St}_{5+5}\, \widehat{C}_5$. Common wood-sorrel (*Oxalis Acetosella*) abounds in woods.

Order Linaceæ, the Flax order. The flowers are usually pentamerous. The stamens are 5, alternate with the petals, with 5 intermediate teeth or abortive stamens, styles 5 (fig. 346). The seed-vessels often

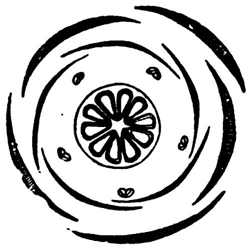


Fig. 345.

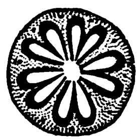


Fig. 347.

Fig. 346.

show 10 divisions in place of 5 in consequence of the folding inwards of the back of the carpels (figs. 345 and 347). The formula of the order is—$S_5\, P_5\, St_{5+0}\, \widehat{C}_5$. Mucilage, fibres, and oil are yielded by the plants of the order. Oil-cake is prepared by bruising the seeds; it is used for fattening cattle. The powdered cake constitutes linseed meal, which is used for poultices.

Figs. 345 to 348 illustrate the natural order Linaceæ.

Fig. 345.—Diagram of the Flax plant, showing five imbricate sepals, five contorted petals, five alternating stamens, and five divisions of the ovary, each of which is divided into two by a spurious septum from the dorsal suture.

Fig. 346.—Syncarpous pentacarpellary ovary of the Flax plant, with five distinct styles.

Fig. 347.—Transverse section of the syncarpous fruit of the Flax plant, showing the five cells or loculaments, divided each into two by a spurious dorsal septum.

In the purging flax (*Linum catharticum*) the leaves are

Fig. 348.

opposite, while in the other British species the leaves are scattered (fig. 348).

QUESTIONS.

1. What is meant by phanerogamous plants?
2. Give the character of the class Dicotyledones.
3. Define Thalamifloræ.
4. Give the essential characters of the natural order Ranunculaceæ.
5. Describe the fruit of the crowfoot family.

Fig. 348.—*Linum usitatissimum*, the Flax plant. It is the Hebrew Pishtah referred to in Exod. ix. 31, Josh. ii. 6, and in many other passages of the Old Testament; and it is the Linon of Matt. xii. 20.

6. How does the position of the seed differ in crowfoots ?

7. How do the anthers of crowfoots open ?

8. What are the species of ranunculus called buttercups? Separate them from each other.

9. Mention some of the Ranunculaceæ in which the corolla is wanting.

10. Mention some irregularities in the petals of the crowfoot order.

11. Give the essential characters of Nymphæaceæ.

12. What kind of disk is met with in water-lilies ?

13. Give the essential characters of Papaveraceæ.

14. What are the points of resemblance between Papaveraceæ and Ranunculaceæ ?

15. What are the points of resemblance between Papa veraceæ and Cruciferæ ?

16. What kind of juice is yielded by Papaveraceous plants ?

17. What plant yields opium ?

18. Separate the genus Papaver from the genus Meconopsis.

19. Give the essential characters of Cruciferæ.

20. Mention the kinds of fruit which are met with in the cruciferous order.

21. What is contained in the seed of crucifers ?

22. Mention peculiarities in regard to the embryo of Cruciferæ.

23. On what characters are subdivisions of the order Cruciferæ founded ?

24. Mention a few cruciferous British plants.

25. Give the essential characters of Violaceæ.

26. Mention a peculiarity in the petals.

27. Mention some peculiarities in the stamens.

28. What is the nature of the stigma ?

29. Define Caryophyllaceæ, and mention some plants found in the order.

30. What are the subdivisions of the chickweed order ? *Give their* characters.

31. Explain the mode in which the seed-vessels of the carnation and the red campion open.

32. What relation do the valves or teeth of the seed-vessels of Caryophyllaceæ bear to the styles?

33. What kind of inflorescence occurs in the chickweed or carnation order?

34. Describe the nature of the placenta, and the position of the embryo in that order.

35. Give the essential characters of Malvaceæ.

36. Is there any peculiarity in the calyx of mallow?

37. Give the æstivation of the corolla.

38. Give the character of the stamens of mallow.

39. How do their anthers open?

40. What is the nature of their seed-vessels?

41. What are their properties?

42. Give the essential characters of Geraniaceæ.

43. Describe their stamens.

44. Describe the mode in which their seed-vessels open to scatter the seed.

45. Why is geranium called cranesbill?

46. Distinguish geranium from erodium (the storksbill).

47. Mention a peculiarity in the calyx of the pelargonium.

48. Give the characters of the order Oxalidaceæ.

49. Give the formula for the order.

50. Mention a peculiarity in the seeds of oxalis.

51. How do Oxalidaceæ differ from Geraniaceæ?

52. Give the characters of the natural order Linaceæ.

53. Give the formula for the order.

54. What are the products yielded by Linaceæ?

55. How does purging flax differ from the other British species?

We now pass on to the second sub-class of Dicotyledonous plants.

SUB-CLASS II.—CALYCIFLORÆ.

In the plants belonging to this sub-class, calyx and corolla are present; the petals are distinct or united, and the stamens are attached to the calyx—being perigynous or epigynous.

Section 1.—POLYPETALÆ.—Petals separate, stamens attached to the calyx, perigynous or epigynous.

This section may be illustrated by the leguminous and rosaceous orders, as well as by willow-herbs, stonecrops, saxifrages, and umbelliferous plants.

Fig. 349.

Fig. 350.

Order LEGUMINOSÆ, the Pea and Bean Family.—

Figs. 349-353.—Organs of fructification of *Lathyrus odoratus*, Sweet-pea, a papilionaceous flower, showing the structure of the natural order Leguminosæ.

Fig. 349.—Diagram of the flower, showing five divisions of the calyx, 5 petals, consisting of 2 parts forming the carina, 2 alæ, and the vexillum, which is superior; 10 stamens, diadelphous; ovary 1-celled, formed by a single carpel; one of the ovules shown with its stalk attached to the ventral suture.

Fig. 350.—Longitudinal section of the flower of *Lathyrus odoratus*. *c c*, Calyx, with five segments. *e*, Vexillum or standard, being the superior petal. *a*, One of the alæ, or wings. *c a*, One-half of the carina, or keel. *t*, Tube of the stamens, the filaments being united in two bundles (diadelphous). *o*, Ovary laid open, showing the ovules attached to the placenta, on the ventral or upper suture. *s*, Stigma, at the apex of the style, which is continuous with the ventral suture.

Calyx has five segments (fig. 350 *c c*), with the odd one inferior. Petals usually 5 (figs. 349, 350), and unequal, often papilionaceous (figs. 171-173, p. 123), with the odd petal superior (fig. 350 *e*), stamens usually monadelphous or diadelphous (figs. 350 *t*; 182, p. 135). Ovary superior, 1-celled, consisting usually of a solitary carpel (fig. 350 *o*). Fruit a legume (figs. 351; 213, p.

Fig. 351.

Fig. 352.

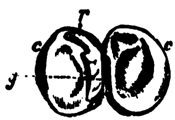


Fig. 353.

153). Seeds solitary or several (fig. 352); embryo exalbuminous (figs. 353; 20, p. 13).—Herbaceous plants, shrubs, or trees, with alternate, usually compound leaves,

Fig. 351.—Fruit, a legume or pod, formed by two valves, opening by the ventral and dorsal suture. Seeds attached on each side of the ventral suture, curved upon themselves, having a marked hilum and stalk.

Fig. 352.—A seed separated. *f*, Stalk of seed. *c*, Point where nourishing vessels reach the embryo. *m*, Opening in seed.

Fig. 353.—Embryo, which occupies the entire seed after the covering is removed. *c c*, Two cotyledons separated: they are fleshy and remain underground during germination. *g*, Young stem. *r*, Radicle.

having two stipules at the base of the petiole (fig. 100, p. 63). The flowers are frequently papilionaceous, and the fruit is commonly leguminous; and by the presence of one or other of these characters the order may be recognised. The formula for Leguminosæ is—$\widehat{S_5}\,P_5\,\widehat{St_{5+4+1}}\,C_1$.

The plants of the order are widely distributed over the globe.

The order has been divided into three sub-orders:—1. *Papilionaceæ;* papilionaceous flowers, petals imbricated in æstivation, and upper one exterior. *Examples*—Broom, pea. 2. *Cæsalpinieæ;* flowers irregular, petals imbricated in æstivation, upper one interior. *Examples*—Cassia, logwood. 3. *Mimoseæ;* flowers regular, petals valvate in æstivation. *Example*—Gum-arabic tree.

This is a very extensive and a very important natural order. It embraces many valuable medicinal plants, such as those yielding senna, gum-arabic, tragacanth, catechu, and kino; important dyes, as indigo and logwood; many valuable timber-trees, as locust-tree and rosewood; plants furnishing nutritious food, such as the bean, pea, and clover. The properties of the order may be considered in general as wholesome, although it contains some poisonous plants, such as the Calabar bean.

All the British Leguminous plants belong to the sub-order Papilionaceæ, having pea-like blossoms. To illustrate the order, we shall take the common broom (*Sarothamnus scoparius*). The broom is a shrubby plant, having a stem 2 to 3 feet high, with angular smooth

branches; the leaves are stalked, and are arranged in threes (ternate); the upper ones, however, are simple (not compound); the leaflets are inversely egg-shaped. The flowers are large, bright yellow, and are either solitary or in pairs, with short stalks; the calyx is two-lipped, the upper lip having two minute teeth, the lower three; the standard is large and covers the other parts of the flower in bud; the keel is blunt, and finally falls down; the stamens are monadelphous, and their tube is split on the upper side; the style is long, curved, and thickened upwards towards the stigma, which is small and like the head of a minute pin; the pods are dark-brown and hairy at the edges, containing many seeds, and when ripe they open in an elastic manner and often with a marked noise.

Most of the British plants in the order are diadelphous. This character is seen in vetches, everlasting pea, trefoils, and bird's-foot trefoil, in which there are nine stamens united by their filaments, and one separate (fig. 182, p. 135), as shown in formula, p. 262. The leaves of the British species are either solitary, or they are ternate or pinnate. Papilionaceous flowers and legumes are present in all the British plants of the order.

Order Rosaceæ, the Rose Family (figs. 354 to 364).—Calyx 4-5-lobed (fig. 355 *c c*), the fifth lobe superior. Petals as many as the divisions of the calyx, often 5 (fig. 355 *pe*), sometimes wanting, generally regular. Stamens perigynous, definite or indefinite (fig. 355 *e*). Ovaries superior, either solitary or several, one-celled (fig. 357). Fruit, achenes (figs. 363; 206,

p. 146) or drupes (fig. 358), or follicles, or pomes (pp. 155, 158).—Herbaceous plants, or shrubs, or trees, with simple or compound, alternate, stipulate leaves (fig. 116, p. 70). They are found chiefly in the cold and

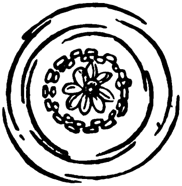


Fig. 354.

Fig. 355.

Fig. 356.

temperate climates of the northern hemisphere. Some are found on high mountains within the tropics, and a few occur in warm regions. The superior odd lobe of the calyx distinguishes this order from Leguminosæ.

The order has been divided into the following sub-orders :—1. *Roseæ;* calyx-tube becoming fleshy and covering numerous hairy achenes (fig. 362). *Example* —Rose. 2. *Potentilleæ;* fruit consisting of numerous achenes on an elevated receptacle. *Example*—Strawberry (fig. 167, p. 122 ; 217, p. 154). 3. *Sanguisorbeæ;* petals 0, stamens definite, often 4 (fig. 364). *Example* —Lady's-mantle (fig. 206, p. 146). 4. *Amygdaleæ;* styles terminal, fruit a drupe (fig. 197, p. 143). *Example*

Figs. 354-361.—Organs of fructification of a kind of bramble (*Rubus strigosus*), illustrating the natural order Rosaceæ.

Fig. 354.—Diagram of the flower, with five divisions of the calyx, 5 petals, indefinite perigynous stamens, and numerous carpels.

Fig. 355.—The flower cut vertically. *c c*, Calyx. *pe*, Petals. *e*, Stamens. *d*, Disk, lining the base of the calyx, upon which the stamens are inserted. *pi*, Pistil composed of several carpels.

Fig. 356.—Anther separated, with the upper part of the filament seen on the outside.

—Cherry (fig. 141, p. 102). 5. *Spiræeæ;* fruit consisting of numerous follicles. *Example*—Queen of the meadow. 6. *Pomeæ;* fruit a 1-5-celled fruit like the apple (pome). *Example*—Apple.

Fig. 360.

Fig. 357.

Fig. 358.

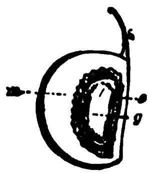


Fig. 359.

Fig. 361.

Many of the plants of the order yield edible fruits, such as raspberries, strawberries, brambles, apples, pears, quinces, plums, cherries, almonds, peaches, nectarines, and apricots. Some are astringent, others yield prussic acid.

We shall illustrate the order, in the first place, by the genus Rosa, which is easily distinguished by its fruit, commonly called the hep of the rose. This fruit consists of the calyx, with a fleshy covering inside, bearing numerous hairy achenes, each terminated with a long style. The tube of the calyx is contracted at its orifice, and the limb of the calyx is seen on the top of

Fig. 357.—Ovary, *o*, cut vertically. *g*, Suspended seed. *s*, Lateral style.

Fig. 358.—Fruit. *f*, Succulent carpels with the persistent calyx, *c*, connected with which the withered filaments are seen.

Fig. 359.—Vertical section of a carpel. *s*, Lateral style. *m*, Mesocarp. *e*, Endocarp. *g*, Seed.

Fig. 360.—Horizontal section of the exalbuminous seed. *t*, Integument. *c*, Cotyledons of the embryo.

Fig. 361.—Embryo isolated. It fills the entire seed.

the hep. The roses have prickly stems, pinnate leaves, with stipule adherent to the leaf-stalk (fig. 67, p. 44). The Burnet rose is the common Scotch rose, found abundantly on sandy soils. The dog-rose, the sweet-brier (fig. 362), and the downy-leaved (tomentose) rose, belong to the genus.

Fig. 362.

Fig. 363.

Examine the common wild strawberry (*Fragaria vesca*), and you will find a short stem sending off runners, which root as they extend, bearing ternate leaves; flowering stem erect, and producing few flowers; a double calyx with five large and five small segments alternating; five petals (fig. 167, p. 122), numerous stamens adhering to the calyx; single-seeded carpels on the top of a succulent receptacle (fig. 217, p. 154); styles

Fig. 362.—Polypetalous flower of *Rosa rubiginosa*, the sweet-brier. *b*, Bract or floral leaf. *ct*, Tube of calyx, which forms the conspicuous part of what is commonly called the fruit. *cf*, *cf*, *cf*, *cf*, Sepals of the calyx. *p p p p*, Petals without a claw. *e*, Stamens attached to the calyx.

Fig. 363.—Carpel of strawberry. *o*, Ovary. *t*, Style arising from near the base, and becoming basilar by the mode in which the ovary is developed; the style, however, still indicating the organic apex of the ovary.

lateral, arising from near the base (fig. 363). In the strawberry the edible part is the juicy receptacle, whereas in the raspberry the receptacle is not eaten, but the succulent carpels are used. The cinquefoil (*Potentilla*) differs from the strawberry in having a dry receptacle. In the lady's-mantle (*Alchemilla vulgaris*,

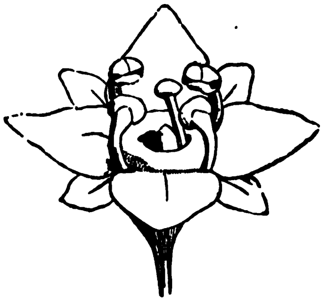


Fig. 364.

fig. 364) the corolla is wanting, the parts of the flower are arranged in fours, the fruit consists of a single achene, and the style is lateral; the leaves are rounded and plaited, and from 7-9-lobed. The formula for Alchemilla is—$\overset{\frown}{S_{4+4}}\,P_0\,St_4\,C_1$. The cherry and peach have drupaceous fruit; the apple and pear have fleshy fruit formed of five carpels, and the queen of the meadow (*Spiræa*) has follicles for its fruit.

Order ONAGRACEÆ, the Willow-herb Family. Floral symmetry binary or quaternary. Calyx su-

Fig. 364.—Flower of Lady's-mantle (*Alchemilla vulgaris*), with a double calyx of 8 parts, four stamens, a basilar style, and a thick ring in the throat of the calyx.

perior, and four-valved; sometimes succulent, as in the fuchsia. Seeds sometimes hairy as in willow-herb. This order is illustrated by the genera epilobium,

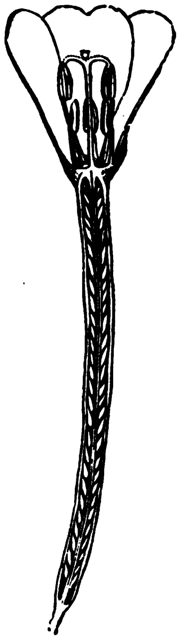


Fig. 365.

œnothera (evening primrose), circæa (enchanter's nightshade), trapa (the water-chestnut), and fuchsia.

Order CRASSULACEÆ, the Stonecrop Family. Fleshy plants (fig. 367), with pentamerous symmetry (figs.

Fig. 365. Flower of Willow-herb (*Epilobium*), showing the long pod-like ovary adherent to the tube of the calyx, the epigynous *petals and stamens*, with the single style and papillose lobed stigma.

366, 368). Stamens often 10 or more, with scales

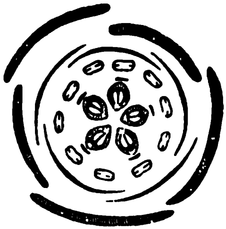


Fig. 366.

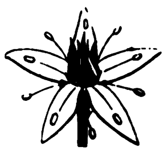


Fig. 368.

Fig. 369.

Fig. 367.

at their base. Carpels separate (not coherent). Fruit composed of follicles (fig. 369). The species often

Fig. 366.—Diagram of Stonecrop (*Sedum*) showing 5 sepals, 5 petals, 10 stamens in 2 rows, and 5 carpels with hypogynous scales.

Fig. 367.—Biting Stonecrop (*Sedum acre*), with its secund yellow flowers in a racemose cyme.

Fig. 368.—Flower of *Sedum acre*, showing 5 petals, 10 stamens in 2 verticils, and 5 carpels forming the pistil.

Fig. 369.—Fruit of *Sedum acre*, consisting of 5 follicles with glands at their base. See Formula of *Sedum* (page 202, line 16).

grow in rocks or walls; some are acrid, as the biting stonecrop (*Sedum acre*, fig. 367). The house-leek grows on the tops of houses.

Order SAXIFRAGACEÆ, the Saxifrage Family. Flowers are indefinite racemes or corymbs (fig. 370). Symmetry

Fig. 370.

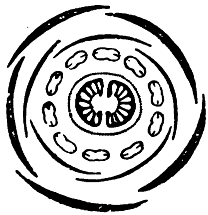


Fig. 371.

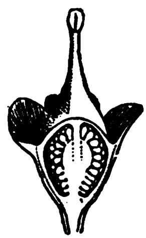


Fig. 372.

of the flowers quaternary or quinary (fig. 371). Calyx adherent more or less to the ovary (fig. 372). Stamens perigynous. Fruit bicarpellary, usually two-

Fig. 370.—Rue-leaved Saxifrage (*Saxifraga tridactylites*), with wedge-shaped, trifid leaves, and flowers in a racemose cyme.

Fig. 371.—Diagram of the flower of Saxifraga tridactylites, with 5 divisions of the calyx, 5 petals, 10 stamens in 2 rows, and a bicarpellary pistil with numerous ovules.

Fig. 372.—Carpel of Saxifrage, cut vertically, showing the adherent calyx, the beak of the carpel or style and stigma, and the ovules attached to the placenta.

beaked, and opening between the beaks. The plants are found chiefly in alpine districts. On the Scottish mountains there are many showy saxifrages, such as Saxifraga aizoides, S. stellaris, S. hypnoides, S. oppositifolia showing its large purplish-red blossom in April; S. nivalis, S. rivularis met with on Lochnagar, and S. cernua, on the summit of Ben Lawers. They are very interesting plants, and attract the notice of all mountain travellers. Another species, S. granulata, is an early spring plant which occurs abundantly in woods.

Order UMBELLIFERÆ, the Hemlock Family (figs. 373-379).—Calyx superior, 5-toothed or entire. Petals

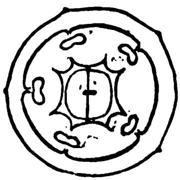


Fig. 373.

Fig. 374.

5, inserted on the outside of a fleshy epigynous disk, often with inflexed points (figs. 374, 377). Stamens 5, alternate with the petals (figs. 373, 374, 375, 377). Ovary inferior, 2-celled, crowned with a double disk (376, 377 *ge*); ovules solitary, pendulous; styles 2, distinct

Figs. 373-379 illustrate the natural order Umbelliferæ.

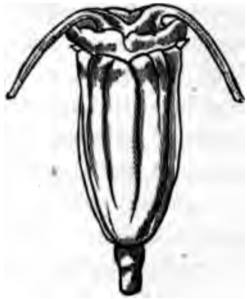
Fig. 373.—Diagram of the flower of the common carrot (*Daucus Carota*) with a 5-toothed calyx, 5 inflexed petals, 5 stamens, and fruit formed by two carpels, with ridges and albumen.

Fig. 374.—The flower viewed from above, showing the petals with inflexed points and 5 stamens. *ge*, Epigynous disk.

(figs. 376, 377 *s*). Fruit (figs. 378, 379) formed by two

☿

Fig. 375.



♀

Fig. 376.

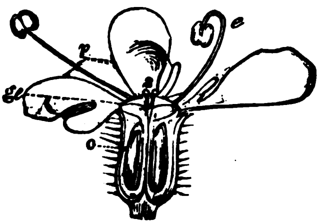


Fig. 377.

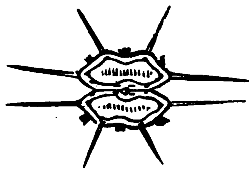


Fig. 378.

achenes, which adhere by their faces to a common axis, from which they separate and are suspended when

Fig. 375.—Perfect flower of asafœtida (*Narthex Asafœtida*), with obsolete 5-toothed calyx, 5 oblong petals, one showing inflexed point, 5 stamens, epigynous disk, and 2 slightly-curved styles.

Fig. 376.—Pistillate flower of asafœtida with obsolete-lobed calyx, 2 deflexed styles surmounting the cremocarp.

Fig. 377.—Vertical section of the flower of carrot. *p*, Petals with inflexed points. *e*, Stamens, one incurved at the apex. *o*, Ovary formed by two carpels, adherent to the calyx throughout. *s*, Styles and stigmas. *ge*, Epigynous disk or stylopod.

Fig. 378.—Horizontal section of the fruit (cremocarp) of carrot *with bristly* ridges.

ripe (fig. 380); each achene is traversed by ridges. In the substance of the covering of the fruit there are frequently oil-cavities called vittæ. Seeds pendulous (fig. 379 *g*), embryo minute, at the base of abundant horny albumen (fig. 379 *e*).—Herbaceous plants, often with hollow and furrowed stems, having alternate, rarely opposite, variously divided, sheathing leaves, and umbel-

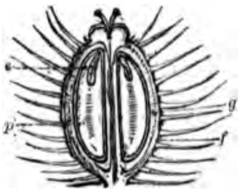


Fig. 379.

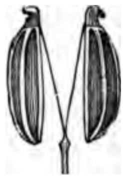


Fig. 380.

late flowers (fig. 142, p. 103). They are found chiefly in the northern parts of the northern hemisphere. In warm countries they occur at high elevations. The order has been divided according to the number and size of the ridges on the fruit, the presence or absence of vittæ, and the form of the albumen.

The properties of the plants of this order are various. Some yield articles of diet, others gum-resins and oily substances, while others are highly poisonous. According to their qualities, the species have been divided into—1. Those which are harmless, and are used as esculent vegetables—carrot, parsnip, and parsley.

Fig. 379.—Vertical section of the fruit. *f*, Pericarp. *g*, Suspended seeds. *p*, Flat albumen. *e*, Embryo.

Fig. 380.—The fruit of Fennel, separating into 2 achenes (mericarps) suspended by the split carpophore. Styles, stylopod, and the ridges of the fruit are seen.

2. Those producing a gum-resin, often having a fetid odour from the presence of a sulphur-oil, and which are used as antispasmodics and stimulants—asafœtida and galbanum. 3. Those yielding a volatile oil, which renders them carminative and aromatic—caraway, coriander, anise, cummin. 4. Those which are poisonous, in consequence of the presence of an acrid and narcotic juice—hemlock and fool's parsley.

Many native plants may be used to illustrate the Umbel-bearing family. In the early months of summer the chervil (*Anthriscus*) and the cicely (*Myrrhis*) will answer the purpose well. It is of importance to see the fruit fully formed, and hence the characters of the plants are best seen later in the season. The sweet cicely (*Myrrhis odorata*), which is common on the banks of streams, may be taken as an illustration, more especially as from its early flowering it perfects its fruit sooner than others. It is a highly aromatic plant, two or more feet in height. The leaves are large, thrice-pinnate, and the leaflets are pinnatifid. The leaves are downy below, and they are marked above by white spots or patches. The flowers are white, arranged in compound umbels. The calyx-limb is very minute and scarcely visible. The petals are inversely heart-shaped, with a turned-in point. The fruit is large, composed of two achenes united, which when ripe separate, and are for a time suspended by their apex, by means of thread-like cords. The covering of the achenes is double, the inner one being close to the seed, the other being folded into hollow ridges. At the top of the fruit the disk and two styles

are easily observed. By cutting across the fruit the white curved albumen will be seen.

QUESTIONS.

1. Give the characters of the sub-class Calycifloræ.
2. Give the characters of the section Polypetalæ of the calycifloral sub-class.
3. Give the characters of Leguminosæ, including calyx, corolla, stamens, and fruit.
4. What kind of corolla is found in the British leguminous plants? Give an example.
5. Give a formula for leguminous plants.
6. What are the sub-orders of Leguminosæ?
7. Give the essential characters of these sub-orders.
8. Give an illustration of each of the sub-orders.
9. What are the properties of Leguminosæ?
10. Mention a poisonous plant of the order.
11. Mention a peculiarity in the mode in which the legume of the broom opens.
12. Give the character of the style of the broom.
13. What kind of stamens are met with in the British leguminous plants?
14. Mention some common leguminous plants used for food.
15. What kind of leaves are most commonly met with in leguminous plants?
16. Give the characters of the natural order Rosaceæ.
17. How is the calyx of Rosaceæ distinguished from that of Leguminosæ?
18. What kind of fruit occurs in Rosaceæ?
19. Mention the sub-orders of Rosaceæ.
20. Give the essential characters of each of the sub-orders.
21. Mention plants illustrating each of the sub-orders.
22. What are the usual properties of the plants belonging to the order Rosaceæ?
23. Give a description of the hep of the rose.

24. Explain the difference between the fruit of the strawberry and that of the raspberry.

25. Mention a peculiarity in the style of the strawberry.

26. What constitutes the succulent part of the strawberry, and what does it bear on its surface?

27. How does the fruit of the common cinquefoil differ from that of the strawberry?

28. Mention a peculiarity in the flower of the common lady's-mantle.

29. Give the essential characters of the order Onagraceæ.

30. Mention plants illustrating the order.

31. What is the difference between the fruit of Epilobium and that of the Fuchsia?

32. Mention a peculiarity in the seeds of Epilobium.

33. Give the essential characters of the order Crassulaceæ.

34. Mention plants illustrating the order.

35. Give the essential characters of the order Saxifragaceæ.

36. Mention some of the Alpine Saxifrages of Britain.

37. Give the essential characters of the Umbelliferous order.

38. Whence is the name derived?

39. Give specially the characters of the fruit of Umbelliferæ, and the mode in which it is scattered.

40. What is meant by the vittæ of umbelliferous plants?

41. What are the properties of Umbelliferæ?

42. Mention plants illustrating different properties in the order.

43. Give the characters of the fruit of the sweet cicely.

We proceed to consider the second Section of the Calycifloral sub-class.

Section 2.—GAMOPETALÆ.—Petals united; stamens usually epigynous. This section includes the orders with united petals, in which the ovary is inferior,

or, in other words, in which the calyx is superior. This section will be illustrated by the woodruff, valerian, harebell, and composite orders.

Order RUBIACEÆ, the Woodruff and Madder Family (figs. 381 and 382). Calyx superior, the limb with 4-5 divisions, sometimes a mere rim (fig. 382 *c*). Corolla tubular or rotate. Stamens 4-5. Fruit usually bilocu-

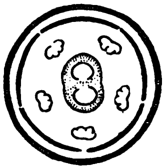


Fig. 381.

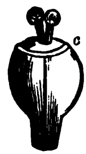


Fig. 382.

lar, each loculament containing one or more seeds. There are three sub-orders :—

a. Galieæ or Stellatæ,—with square stems, whorled leaves, no stipules, one seed in each cavity of the fruit. This is illustrated by the bedstraw (Galium), madder (Rubia), and woodruff (Asperula), in Britain.

b. Coffeæ,—plants of warm climate, with evident stipules, fruit with 1-2 seeds in each loculament, as in the coffee-plant, which has also a succulent fruit.

c. Cinchoneæ,—with distinct stipules and glands, fruit containing numerous seeds in each loculament, as in the Peruvian bark tree (Cinchona), and ipecacuan (Cephäe-

Fig. 381.—Diagram of the flower of Madder (*Rubia tinctorum*), with the rim-like calycine limb, 5 parts of the corolla, 5 stamens, and a 2-celled and 2-seeded ovary.

Fig. 382.—Pistil of Madder, with the adherent calyx-tube, obsolete limb in the form of a mere rim at the top of the ovary, 2 styles and 2 stigmas.

lis). Many of the plants are found in South America. The Peruvian bark trees are met with in the Andes at elevations varying from 5000 to 8000 feet above the level of the sea. Ipecacuan grows in several Brazilian provinces. Both cinchona (yielding quinine) and ipecacuan are now cultivated in India. The plants of the order have tonic and emetic properties. They are used in intermittent fever (ague) and in dysentery. The hard seeds of coffee when roasted are used as a beverage.

Order VALERIANACEÆ, the Valerian Family (figs. 383-

Fig. 383.

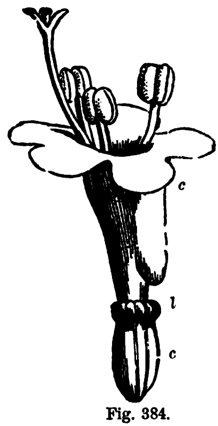


Fig. 384.

385).—Herbs with opposite exstipulate leaves and

Fig. 383.—Diagram of Valerian (*Valeriana officinalis*), showing calycine feathery pappus outside, 5 lobes of the corolla, 3 stamens, and one perfect ovarian cell with a single ovule.

Fig. 384.—Flower of Valerian, with adherent calycine tube, obsolete limb *l*, which becomes pappose, irregular corolla *c*, gibbous at the base and with a 5-lobed limb, 3 stamens, and one style with 3 stigmas.

cymose inflorescence. Calyx superior, limb obsolete or forming a kind of pappus. Corolla tubular, 3-6 lobed, sometimes spurred at the base (fig. 384). Stamens 1-5, inserted on the corolla. Ovary with one cell and 2 abortive ones; ovule solitary. Fruit dry and indehiscent, with 1 fertile cell, sometimes pappose (fig. 385).

Fig. 385.

Natives of temperate climates in Europe, Asia, and America. The plants are usually strong-scented and aromatic. Cats are fond of the odour. Valerian root is used in medicine in nervous affections. The spikenard of the ancients is included in this order.

Order CAMPANULACEÆ, the Harebell Family (figs. 386-393.) — Calyx superior, usually 5-lobed (figs. 387, 388 *c*), persistent. Corolla gamopetalous, usually 5-lobed (fig. 166, p. 122), regular, withering on the stalk. Stamens inserted into the calyx, alternating

Fig. 385.—Fruit of Red Valerian (*Centranthus ruber*), indehiscent, containing one perfect seed (2 others being abortive), and having a feathery pappose calyx-limb *c*, at the apex.

with the corolline lobes, and equal to them in number; anthers free (fig. 388 *e*). Ovary inferior, composed of two or more carpels; ovules indefinite (fig. 389).

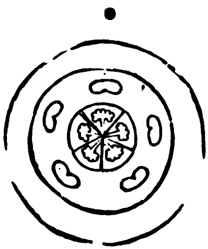


Fig. 386.

Fig. 387.

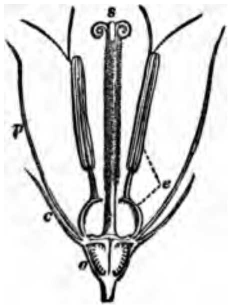


Fig. 388.

Fruit capsular, crowned with the withered calyx and corolla (fig. 390), opening by lateral apertures, or at the apex. Seeds attached to a central placenta; embryo straight, in the axis of fleshy albumen; radicle pointing to the base of the seed (figs. 391-393).—Milky herbs or undershrubs, with alternate, rarely opposite, exstipulate leaves. The flowers in most instances belong to the blue series. They are natives chiefly of northern and temperate regions. They abound in the alpine

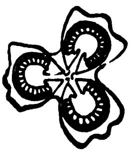
Figs. 386-393.—Organs of reproduction of Rampion (*Campanula Rapunculus*), to illustrate the natural order Campanulaceæ.

Fig. 386.—Diagram of the flower, showing five divisions of the calyx, five divisions of the corolla alternating with them, five alternating stamens, and five cells (loculaments) of the ovary.

Fig. 387.—Flower-bud. *c*, Calyx above the ovary. *p*, Corolla, with valvate æstivation.

Fig. 388.—Vertical section of the flower. *c*, Calyx above the ovary, *o*. *p*, Gamopetalous corolla. *e*, Stamens with bilocular anthers. *s*, Lobed stigma at the apex of the style which is covered with collecting hairs. *o*, Ovary containing numerous ovules attached to a central placenta.

districts of Europe and Asia, and are also frequent in North America. The milky juice found in the plants of this order has acrid properties. The roots and young shoots of rampion (*Campanula Rapunculus*) are used as articles of diet.



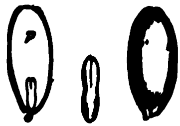


Fig. 389. Fig. 390. Figs. 392. 393. 391.

The Campanulaceæ can be most easily illustrated by the common harebell of our fields, called *Campanula rotundifolia* (fig. 166, p. 122). The specific name means round-leaved; but this character is not easily seen. It is only the lowest leaves that have this character, and they wither soon. These lower leaves are rounded, cordate, and have stalks; while the upper leaves are sessile and lanceolate or linear. The stem is from 6 to 12 inches high. The flowers are one or more, supported on stalks and drooping. The seg-

Fig. 389.—Horizontal section of the ovary.

Fig. 390.—Fruit crowned by the limb of the calyx, dehiscing by openings at the base.

Fig. 391.—Seed in an entire state.

Fig. 392.—Seed cut vertically. *p*, Perisperm (albumen). *e*, Straight embryo in the axis of the albumen, with the radicle pointing to the hilum (base of seed).

Fig. 393.—Embryo detached, showing its form, the cotyledons, and radicle.

ments of the calyx are narrow. The corolla is bell-shaped, usually blue, sometimes white. The plant is commonly called in Scotland the blue-bell, a name which is given in England to the wild hyacinth.

Order COMPOSITÆ, the Dandelion and Daisy Family

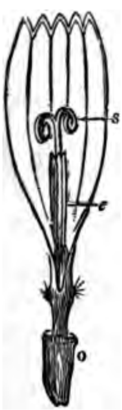


Fig. 395.

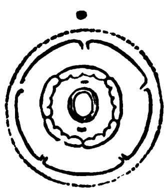


Fig. 394.

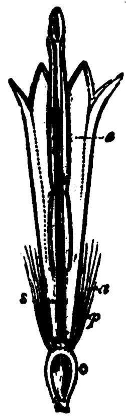


Fig. 396.

(figs. 394-400).—Calyx superior, its limb usually divided

Figs. 394-398.—Organs of reproduction of Compositæ.

Fig. 394.—Diagram of the flower of a Senecio. The outer dotted circle indicates the pappose limb of the calyx, within it is the tubular corolla with five divisions, next five stamens with united anthers, and in the centre the 1-celled 1-seeded ovary.

Fig. 395.—One of the ligulate flowers or florets of *Cichorium Intybus*, Succory or Chicory, belonging to the sub-order Cichoraceæ. *o*, Ovary bearing the calyx on its summit, the limb of the calyx forming a crown surrounding the base of the ligulate (strap-shaped) corolla, which has five divisions at the top. *e*, Cylinder formed by the anthers (synantherous), traversed by the style with its bifid stigma, *s*.

Fig. 396.—Tubular flower of *Aster rubricaulis*, belonging to the sub-order Corymbiferæ, cut longitudinally, to show the erect

into hairs, called pappus (figs. 164, p. 120; 396 *a*). Corolla gamopetalous, ligulate (figs. 395; 164, p. 120), or tubular (figs 396; 183, p. 135), in the latter case usually 5-toothed (fig. 162, p. 120). Stamens usually 5 (fig. 396 *e*); filaments distinct; anthers (figs. 395, 396 *e*) cohering into a cylinder (syngenesious). Ovary in-

Fig. 397.

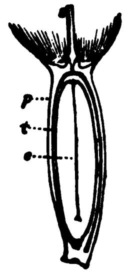


Fig. 398.

ferior, bearing the calyx on its summit (figs 395, 396 *o*, 398), 1-celled; ovule solitary (figs. 208, p. 149; 396, 398); style simple; stigmas two (figs. 164, p. 120; 395). Fruit, an achene (fig. 162, p. 120), crowned with the limb of the calyx (figs. 130, p. 98; 398). Seed solitary, erect, exalbuminous (fig. 398).—Herbs or

ovule *o*, enclosed in the ovary; when ripe this forms an achene. *p*, United petals. *a*, Pappus, consisting of the altered limb of the calyx. *e*, Stamens with their united anthers, attached to the corolla. *s*, Style traversing the antherine tube.

Fig. 397.—Style of Vernonia with bifid hairy stigma.

Fig. 398.—Ripe fruit of a Senecio, cut vertically. *e*, Exalbuminous embryo. *t*, Spermoderm or covering of the erect seed. *p*, Pericarp, consisting of ovarian wall, with the seed in the interior. *s*, Style.

shrubs, with alternate or opposite, exstipulate leaves, and heads of flowers, called florets, which have either stamens and pistils together, or are pistillate and staminate, and are surrounded by bracts in the form of an involucre (fig. 128, p. 97).

This is one of the largest, and, at the same time, one of the most important natural families in the vegetable kingdom. The plants were all included by Linnæus in his class XIX., Syngenesia, and were divided into five orders (page 212). They amount to 10,000 species, and are variously distributed over all quarters of the world.

This order has been divided into three sub-orders; —1. Cichoraceæ (*cichorium*, chicory), having the florets all ligulate. 2. Cynarocephalæ (*cynara*, the artichoke), having the florets all tubular; style swollen below the point where it divides; involucre hard, conical, and often spiny. 3. Corymbiferæ (*corymbus*, a corymb, and *fero*, I bear), having tubular florets in the centre, and ligulate in the circumference; style not swollen, involucre hemispherical, leafy, or scaly, seldom spiny.

Sub-order *Cichoraceæ* (fig. 399).—Most of the plants of this sub-order yield a milky juice, which is bitter, astringent, and sometimes narcotic. By cultivation some of them are rendered esculent. Chicory, dandelion, lettuce, and hawkweed, are among the plants of this section.

Sub-order *Cynarocephalæ* (fig. 143, p. 104).—The plants of this sub-order are usually bitter and tonic. The bitterness is often much lessened by cultivation,

and the plants become esculent. Thistles, burdock, and artichoke, are found in this division.

Sub-order *Corymbiferæ* (fig. 128, p. 97).—The plants of this sub-order have the general bitterness of

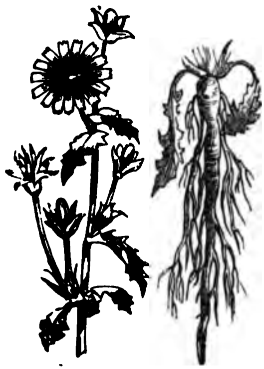


Fig. 399.

the order, and some of them have an aromatic odour, from the presence of volatile oil. Chamomile, colts-foot, the sunflower, and the daisy, are among the plants of this section.

This large order may be illustrated by many common plants. We shall describe a plant in each of the divisions. The common dandelion (*Leontodon Taraxacum*), called so (dent de leon) from the tooth-like margins of its leaves, is a good example of the sub-order Cichoraceæ. In this plant the leaves are radical, and have a pinnatifid form, to which the name runcinate

Fig. 399.—*Cichorium Intybus*, Chicory plant, with its compound flowers and large root, which is often roasted and mixed with coffee.

has been given, because the edges have divisions like

Fig. 400.

Fig. 400.—Runcinate leaves, *a*, and radical peduncles or multifloral scapes, *b c*, of Dandelion (*Leontodon Taraxacum*). In the unexpanded head (capitulum) of flowers, the row of bracts forming the involucre is seen. The expanded head, *c*, consists of numerous ligulate florets, sessile on a flattened receptacle.

the teeth of a saw pointing downwards. The stalk bearing the head of flowers is hollow, and arises singly from the midst of the radical leaves. The heads consist entirely of yellow ligulate flowers, surrounded by rows of bracts, the outer row becoming usually deflexed as the fruit ripens. The ligulate florets are situated on a receptacle, which is at first succulent, but afterwards becomes dry and convex in order to scatter the fruit. The calyx-limb consists of hairs at the top of the ovary. The corolla is ligulate, placed also above the ovary, and it encloses 5 stamens, with united anthers, forming a tube through which the style passes. The fruit is an achene—*i.e.* a dry seed-vessel with a single seed, scattered by means of the pappus, which elongates so as to form a sort of parachute (fig. 130, p. 98). The achene is suddenly contracted above, and forms a slender beak. The plant yields a milky juice, and its roots have been used for chicory.

The common thistle (*Carduus lanceolatus*) belongs to the sub-order Cynarocephalæ. The leaves are white and cottony below, pinnatifid, and the segments end in sharp spines; prolongations from the bases of the leaves run down the stem, which is from three to four feet high, and has strong spiny wings. The heads of flowers terminate the axes, and they are either solitary or two or three together. The bracts covering the heads of flowers are spiny, and form a united egg-shaped involucre (fig. 143, p. 104). The florets are tubular, placed above the ovary. The hairs constituting the limb of the calyx are above the ovary,

and are united into a ring at the base; they ultimately fall off and leave the fruit (achene) clear.

The common daisy (*Bellis perennis*) belongs to the sub-order Corymbiferæ. The leaves of the plant are radical—that is, produced from a short stem, and lying along the ground; they are inversely ovate, and like a spatula in form, the margin being slightly divided. The stalk bearing the head of flowers arises from the centre of the radical leaves. The heads of flowers are surrounded by two rows of equal floral bracts. The florets are placed on a conical receptacle. There are two kinds of florets; the outer white florets (sometimes tipped with red) are ligulate, and have pistils only. The inner yellow florets are tubular, and have both stamens and pistils. The anthers are united round the style. There is no pappus. The fruit is compressed. After the fruit has fallen, the conical receptacle is well seen.

Order Dipsacaceæ, the Scabious and Teazel Family. These plants have their flowers in heads (capitula, fig. 139, p. 101), and are chiefly distinguished from Compositæ by the four-membered (tetramerous) symmetry of their florets, their distinct (non-coherent) anthers, and by the additional covering below the calyx, called an epicalyx. This epicalyx in the teazel is spiny, and is used by Fullers in dressing cloth.

QUESTIONS.

1. Give the essential characters of the gamopetalous section of Calycifloræ.
2. Give the characters of the order Rubiaceæ.

3. Describe the sub-orders of Rubiaceæ, and give an example of each.

4. What are the general properties of the order?

5. Mention some of the plants of the order, including some British genera.

6. What kind of fruit is met with in coffee?

7. What part of the coffee is used to furnish a beverage?

8. Give the characters of the order Valerianaceæ.

9. Mention a peculiarity in the calyx of Valerian.

10. Describe the fruit of Valerian.

11. What are the properties of the order Valerianaceæ?

12. Give the characters of Campanulaceæ.

13. Mention a peculiarity in the mode of opening in the capsule of the common harebell.

14. What kind of juice is met with in Campanulas?

15. What plants receive the name of blue-bell?

16. Give the essential characters of Compositæ.

17. What is the usual character of the calyx of Compositæ? and what is its relation to the ovary?

18. What kind of fruit occurs in Compositæ?

19. What kinds of corolla are seen in Compositæ?

20. What is the inflorescence of Compositæ?

21. Give the characters of the anthers of Compositæ.

22. What are the properties of Compositæ?

23. Give the sub-orders of Compositæ, and give an example of each.

24. Give the characters of these sub-orders.

25. In what sub-order is milky juice met with?

26. Describe the parts of the head of the dandelion.

27. Describe the parts of the head of a thistle.

28. Describe the parts of the head of the daisy.

29. What form of receptacle occurs in the daisy?

30. Give the essential characters of the order Dipsacaceæ.

31. How do they differ from Compositæ?

32. Mention some of the plants of the order.

We now proceed to describe the third sub-class of dicotyledonous plants. It may be illustrated by the

heath, the gentian, the convolvulus, the borage, the potato, the dead-nettle and the figwort orders. The characters of some of the orders will be put in contrast, so as to shorten the description and point out the chief marks of distinction between them.

Sub-Class III.—Corolliflorae.

Calyx and corolla present. Corolla gamopetalous, hypogynous, usually bearing the stamens.

We commence with the heaths, in which the stamens are usually not attached to the corolla.

Order Ericaceæ, the Heath Family (figs. 401-403).—Calyx 4-5 cleft, persistent. Corolla hypogynous (fig. 403), often withering on the stalk. Stamens equal in number to the segments of the corolla, or twice as many, inserted with the corolla, and either free from it or attached to its base; anthers 2-celled, usually having appendages at the base (fig. 403) or apex, dehiscing by pores or clefts at the top. Ovary free (fig. 403), many-celled; ovules numerous, attached to a central placenta; style 1, stigma 1. Fruit capsular or berried, many-celled. Seeds numerous, minute.—Shrubs, undershrubs, or herbaceous plants, with evergreen, often rigid, entire, verticillate or opposite, exstipulate leaves. The order contains many beautiful and showy plants, which abound at the Cape of Good Hope, and species of which are found also in Europe, North and South America, and Asia.

The plants of the order are not remarkable for medicinal virtues. There are six species of the genus

Erica natives of Britain: two of these, *Erica cinerea* and *Erica Tetralix*, are common; two are peculiar to Ireland, *E. Mackaiana* and *E. mediterranea;* and two are

Fig. 401.

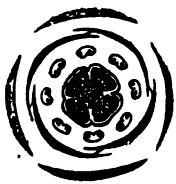


Fig. 402.

Fig. 403.

common to England and Ireland, *E. ciliaris* and *E. vagans.* The corollas of these heaths assume pink and white colours. *Calluna vulgaris* is the common heather called ling. It has astringent qualities, and has been used for dyeing. It is commonly made into brooms. The leaves of *Arbutus* (*Arctostaphylos*) *Uva-ursi*, bear-

Figs. 401-403 illustrate the natural order Ericaceæ.

Fig. 401.—*Erica cinerea*, fine-leaved Heath, showing its entire exstipulate leaves and ovate swollen corolla, with a 4-divided limb.

Fig. 402.—Diagram of *Erica*, showing a flower having 4 divisions of the calyx and corolla, 8 stamens, and a 4-valved capsule.

Fig. 403.—Vertical section of the flower of *Erica*, showing calyx, corolla, hypogynous stamens, anthers opening by slits, and having appendages below, and ovary with central placenta and numerous ovules.

berry, are used as an astringent. Some of the species of *Rhododendron*, *Azalea*, *Kalmia*, *Andromeda*, and *Ledum*, have poisonous narcotic qualities.

The order may be illustrated by the common heather and the bell-flowered heath. The common heather (*Calluna*) differs from the heath (*Erica*) in the mode in which its seed-vessel opens. In Calluna the openings take place through the partitions (septa), and the valves separate from the septa. In Erica the openings take place at the back of the cells of the capsule, between the septa which remain attached to the centre of the valves. The common bell-heath (*Erica Tetralix*), called also cross-leaved heath, is shrubby; its narrow leaves are arranged in whorls of four; they are fringed with hairs, and are downy above, their edges being turned back. The flowers are arranged in an umbel-like form. Calyx divided deeply into 4. Corolla bell-shaped. Stamens 8, with spurred anthers. Seed-vessel 4-celled. Ovary hairy. The fine-leaved heath (fig. 401) is called *Erica cinerea*, and it differs from the cross-leaved heath in having ternate smooth leaves, racemose flowers, and a smooth ovary.

Order Epacridaceæ, the Epacris Family.—The Epacris is called Australian heath. It differs from the true Erica in having 5 in place of 4 divisions of its corolla, and in having 1-celled in place of 2-celled anthers.

Order Vacciniaceæ, the Blaeberry and Cranberry Family. This order differs from the heath family in having the whorls of the flower epigynous—that is, *situated* above the ovary.

To show the relations of some corollifloral orders, we shall now take four to illustrate the group with regular flowers, and two to illustrate the group with irregular flowers.

1. *Group of Corollifloral Plants with Regular Flowers.*

Order Gentianaceæ, the Gentian Family (figs. 404-406).—Herbs, rarely shrubs, with opposite, entire,

Fig. 404.

Fig. 406.

Fig. 405.

Fig. 404.—Diagram of the flower of Gentian, showing five parts of the calyx, five imbricate divisions of the corolla, five stamens, and a bicarpellary ovary, with numerous ovules.

Fig. 405.—Vertical section of the flower of Gentianella (*Gentiana acaulis*), showing divided calyx, induplicate corolla, epicorolline stamens, bicarpellary ovary, one-celled, with numerous ovules attached to parietal placentas.

Fig. 406.—Capsule of Gentian, showing the two carpels with parietal placentas and ovules. The carpels are placed to the right and left of the axis.

exstipulate, usually ribbed leaves, and showy variously-coloured flowers. Calyx divided, persistent. Corolla persistent, imbricate, induplicate, often twisted in æstivation, sometimes with a fringed limb. Stamens alternate with the corolline segments. Ovary of 2 carpels, placed to the right and left of the axis, one-celled, with 2 parietal, often introflexed, placentas (fig. 406); style 1; stigmas 2. Fruit a capsule or berry. Seeds numerous, with fleshy albumen and a minute embryo. Natives of almost all parts of the world. Some are found at great elevations, others in hot tropical plains. The plants are bitter, and are used as tonics. Gentian-root, procured from the yellow gentian of the Alps (*Gentiana lutea*) is used in medicine. Red gentians are confined nearly to the Andes and New Zealand; blue-flowered species reach to 16,000 feet on the Himalayas.

Order CONVOLVULACEÆ, the Convolvulus or Bindweed Family (figs. 407 to 409). Herbs or shrubs, usually twining (fig. 409) and milky, with alternate, exstipulate leaves and regular flowers (fig. 408), having a unifloral or multifloral cymose inflorescence. Calyx 5-divided, imbricated, persistent. Corolla plaited. Stamens 5, alternate with the corolline lobes. Ovary free, 2-4-celled; ovules 1-2 in each cell, erect; styles united, often divided at the apex. Capsule 2-4-celled, sometimes by absorption 1-celled, septifragal. (See formula for Convolvulus, page 204, line 19.) Seeds large, with mucilaginous albumen; embryo curved (fig. 409), with crumpled cotyledons. Chiefly natives of the tropics.

The order is characterised by purgative properties, and it contains some important medicinal plants, such

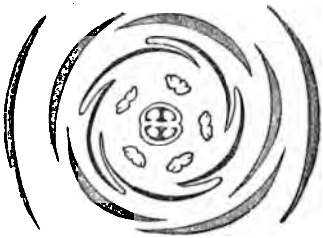


Fig. 407.

Fig. 408.

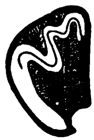


Fig. 409.

as jalap and scammony. C. Batatas (*Batatas edulis*) has a saccharine root or underground stem which is called Sweet Potato.

The Dodders (*Cuscuta*, fig. 34, p. 21) are leafless parasitic twining herbs, generally reckoned a sub-order of Convolvulaceæ.

Fig. 407.—Diagram of the flower of Great Bindweed (*Convolvulus sepium*), showing two bracts, five divisions of the calyx, five lobes of the plaited campanulate corolla, five stamens, and a two-celled ovary with two ovules in each cell.

Fig. 408.—The Scammony plant (*Convolvulus Scammonia*), found in Greece and the Levant. The concrete milky juice of the large root constitutes Scammony, which is imported from Smyrna.

Fig. 409.—Seed of *Convolvulus sepium* cut vertically, showing the curved embryo and plaited cotyledons, with the mucilaginous albumen.

Order Boraginaceæ, the Borage Family (figs. 410-412).—In this order we have plants with a gamosepalous calyx, usually having 5 divisions, a regular 5-cleft

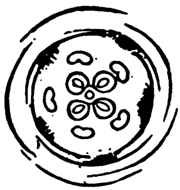


Fig. 410.

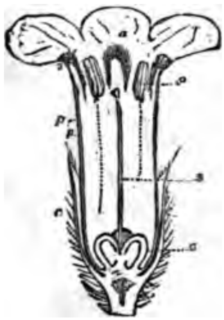


Fig. 411.

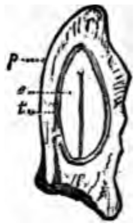


Fig. 412.

corolla, 5 stamens attached to the corolla (fig. 411), and a 4-lobed ovary, which, when ripe, becomes 4 achenes (mericarps, fig. 410). This division of the ovary into four is peculiar, and, along with scorpioidal inflorescence (fig. 146, p. 106) and rough foliage, forms a distinguishing character of the order. It may be illustrated by the comfrey (*Symphytum tuberosum*), common on river-banks, and the forget-me-not (*Myosotis*, fig. 146, p. 106).

Figs. 410-412.—Organs of fructification of *Anchusa italica* (a kind of alkanet), to illustrate the natural order Boraginaceæ.

Fig. 410.—Diagram of the flower, with five imbricated divisions of the calyx, five imbricated segments of the corolla, five stamens, and a 4-lobed ovary.

Fig. 411.—Vertical section of the flower. *c*, Hairy calyx. *p p*, Corolla. *e*, Stamens inserted into the corolla. *a a*, Staminal appendages or corolline scales. *o*, 4-lobed ovary, two of its divisions cut through vertically. *s*, Basilar style.

Fig. 412.—One of the carpels (mericarps) cut vertically. *p*, Pericarp separable from the seed. *t*, Spermoderm, or integuments of the seed. *e*, Embryo, with plano-convex cotyledons.

One of the best plants for showing the four achenes forming the fruit is the common hounds-tongue (*Cynoglossum officinale*), which is abundant on many of our sandy shores amongst bent. Formula for Boraginaceæ $\widehat{S_5}\,\widehat{P_5}\,St_5\,C_4$.

Order SOLANACEÆ, the Potato Family, is another regular-flowered corollifloral order (figs. 413 to 418).

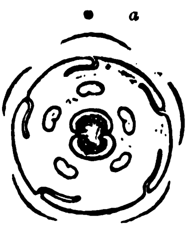


Fig. 413.

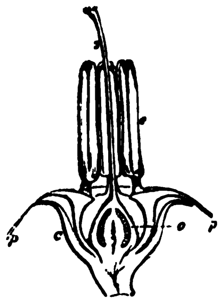


Fig. 414.

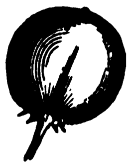


Fig. 415.

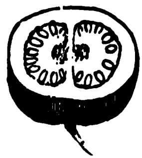


Fig. 416.

Five-membered symmetry is visible in the gamosepalous calyx, the gamopetalous corolla, and the stamens, the

Figs. 413-418.—Organs of fructification of *Solanum tuberosum* (the Potato), to illustrate the natural order Solanaceæ, sub-order Solaneæ.

Fig. 413.—Diagram of the flower, with five divisions of the calyx, five plaited segments of the corolla, five stamens, and a 2-celled ovary with numerous ovules. *a*, Axis.

Fig. 414.—Vertical section of the flower. *c*, Calyx. *p p*, Lower part of the corolla. *e*, Stamens, with porous dehiscence of the anthers. *o*, Ovary. *s*, Style and stigma.

Fig. 415.—Fruit, a berry, not adherent to the calyx.

Fig. 416.—Horizontal section of the two-celled fruit, showing the seeds and placenta.

anthers of which often open by pores (figs. 413 and 414). The ovary consists of 2 carpels, and the fruit is a 2-celled capsule or berry, with numerous seeds (figs. 415, 416). The embryo is often curved (fig. 418). The character of the fruit distinguishes this family from the *Boraginaceæ.* There are two sub-orders in the family: 1. *Solaneæ,*—including the potato, tomato, and capsicum; 2. *Atropeæ,*—comprehending such poisonous narcotic plants as belladonna, henbane, stramonium, and tobacco.


Fig. 417.

Fig. 418.

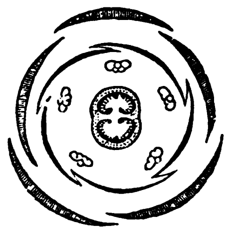


Fig. 419.

In the sub-order Solaneæ, the æstivation of the corolla is valvate or induplicate (fig. 413). In the sub-order Atropeæ, the æstivation of the corolline lobes is imbricate. In fig. 419 there is a diagram of the flower of Atropeæ showing the row of petals overlapping each other (imbricate).

The capsular fruit of the henbane (one of the Atropeæ) opens by a lid (fig. 226, p. 158). The fruit of

Fig. 417.—The seed of the Potato.

Fig. 418.—Vertical section of the seed. *t*, Integument (spermoderm) of the seed. *p*, Fleshy albumen (perisperm). *e*, Embryo, which is curved.

Fig. 419.—Diagram of the flower of *Nicotiana Tabacum* (Tobacco), showing five divisions of the calyx, five imbricate corolline lobes, five stamens alternating with these lobes, and a two-celled (dimerous) ovary.

belladonna is a brownish-black shining two-celled berry. Formula for Solanaceæ—$\widehat{S_5}\,\widehat{P_5}\,St_5\,\widehat{C_2}$.

2. *Group of Corollifloral Plants with Irregular Flowers.*

The plants in this group also are distinguished from each other by the character of their fruit.

Order LABIATÆ, the Dead-nettle Family (figs. 420-424). In this order the calyx and corolla are irregular (figs. 161, p. 119; and 154, p. 111); the latter being

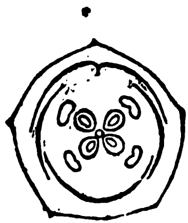


Fig. 420.

Fig. 421.

two-lipped,—the upper lip formed by two united petals, the lower lip by three (figs. 421, 422). There is a want of symmetry as regards the stamens, which are

Figs. 420-424.—Organs of fructification of *Lamium album*, white dead-nettle, to illustrate the natural order Labiatæ.

Fig. 420.—Diagram of the flower, with the pentamerous calyx; pentamerous corolla, having two lips, the upper lip being formed of two united petals, the lower of three; four stamens, in consequence of one being undeveloped, and four divisions of the ovary.

Fig. 421.—Entire flower viewed laterally. *c*, Five-cleft calyx. *t*, Tube of the corolla. *ls*, Upper lip of two petals. *li*, Lower lip of three. *s*, Style.

usually four, didynamous (figs. 420, 421) and sometimes two. The ovary is four-lobed, and, when mature, it forms a fruit consisting of four achenes (figs. 423, 424). The plants of the order have square stems, opposite leaves, and their flowers are in shortened cymes called verticillasters. Their properties are fragrant and aro-

Fig. 422.

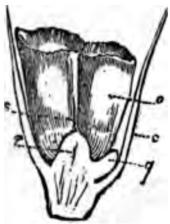


Fig. 423.

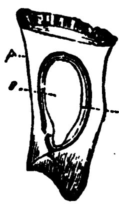


Fig. 424.

matic. The order is well illustrated in the white dead-nettle (*Lamium album*), which is common on hedge-banks. To this order belong mint, lavender, rosemary, hyssop, thyme, sage, and marjoram.

Order SCROPHULARIACEÆ, the Figwort Family (figs. 425-429). In this family there is an irregular calyx and corolla, usually divided into five parts (sometimes

Fig. 422.—The flower cut vertically. *c*, Calyx. *p*, Corolla. *e*, Didynamous stamens. *s*, Style with bifid stigma. *o*, Ovary.

Fig. 423.—Fruit cut vertically, showing the achenes, two of which have been removed. *c*, Persistent calyx. *g*, Fleshy disk or gland. *r*, Receptacle, bearing the style, *s*, which is basilar—*i.e.* arises from the lower part of the achenes. *o*, Two achenes.

Fig. 424.—Achene cut vertically. *p*, Pericarp. *t*, Integument of the seed. *e*, Embryo.

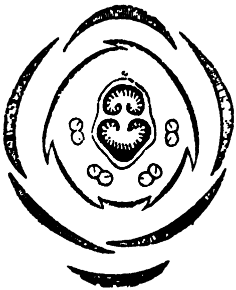


Fig. 425.

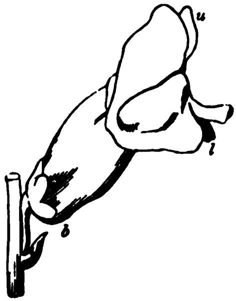


Fig. 426.

Fig. 427.

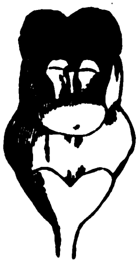


Fig. 428.

Fig. 429.

Figs. 425-429 illustrate the natural order Scrophulariaceæ.

Fig. 425.—Diagram of the flower of *Antirrhinum majus*, frogsmouth, showing a single bract below, five divisions of the irregular calyx, five segments of the irregular personate corolla, four perfect stamens, and a rudiment of a fifth above the ovary, a two-celled ovary composed of two carpels placed posteriorly and anteriorly as regards the axis.

Fig. 426.—Irregular personate flower of *Antirrhinum majus*, frogsmouth.

Fig. 427.—Vertical section of flower of frogsmouth, showing four didynamous stamens attached to the corolla.

Fig. 428.—Irregular-lipped flower of Scrophularia, figwort, with a transverse staminodium or abortive fifth stamen.

Fig. 429.—Two carpels, forming the fruit of Scrophularia, figwort. The carpels are placed anteriorly and posteriorly as regards the axis, *i.e.* one above and the other below.

four). The corolla is lipped or it is personate (figs. 428, 426). Stamens are 4, didynamous (fig. 427), or 2 (fig. 153, p. 111). The fruit is a 2-celled capsule formed by two carpels united (fig. 429). The order differs from the Labiatæ in having a capsular fruit in place of achenes, and in having no aromatic qualities. It may be illustrated by the common knotted figwort (*Scrophularia nodosa*), (fig. 428), foxglove (*Digitalis purpurea*) (fig. 180, p. 134), calceolaria, frogsmouth (figs. 426, 427), snapdragon, and veronica (fig. 153, p. 111).

QUESTIONS.

1. Define the sub-class Corollifloræ.
2. Give the essential characters of Ericaceæ.
3. What is the usual form of the corolla in the heath?
4. Mention two peculiarities in the stamen of the heath.
5. In what part of the world are heaths most abundant?
6. How many kinds of heath are found in Great Britain?
7. How does the blaeberry differ from the heath? To what order is it referred?
8. How does the genus Epacris differ from the genus Erica? To what order is it referred?
9. In what part of the world are the species of Epacris found?
10. Give the essential characters of Gentianaceæ.
11. What are the properties of Gentianaceæ?
12. What plant yields the Gentian root of the shops?
13. What is the usual colour of Gentians?
14. Where are red species of the genus found?
15. Give the essential character of the order Convolvulaceæ.
16. What are the habits of Convolvulaceæ?
17. Mention some important species of the order.

18. What kind of a plant is the Dodder? To what order is it referred?

19. Give the characters of the Boraginaceæ.

20. What kind of fruit is found in the plants belonging to that order?

21. What is the nature of their inflorescence?

22. Give the characters of Solanaceæ.

23. Distinguish the sub-order Solaneæ from the sub-order Atropeæ.

24. What kinds of fruit are found in Solanaceæ? Give examples.

25. Give the essential characters of Labiatæ.

26. What kind of stamens are found in Labiatæ?

27. What kind of fruit occurs in that order?

28. What kind of inflorescence do Labiatæ exhibit?

29. Give the character of their stems and their leaf-arrangement.

30. What are the properties of Labiatæ?

31. Give the essential characters of Scrophulariaceæ.

32. What is the character of their stamens?

33. What is the nature of their fruit?

The fourth sub-class of Dicotyledons will now be shortly considered.

Sub-Class IV.—Monochlamydeæ.

Corolla wanting; a calyx, or what is called a single perianth, present; flowers sometimes Achlamydeous—that is, having neither calyx nor corolla.

Section 1. Angiospermæ. — Monochlamydeous or Achlamydeous plants, having their seeds contained in an ovary, and fertilized by the action of the pollen on a stigma. Under this division are included such plants as the goosefoots, the docks, the nettles, and the catkin-bearing trees.

Order CHENOPODIACEÆ, the Goosefoot Family (fig. 430).—Herbs or undershrubs, with exstipulate, alternate, and occasionally opposite leaves, and small herbaceous, often staminate and pistillate flowers. Perianth divided deeply (fig. 430), sometimes tubular at the base, persistent. Stamens inserted into the base of the perianth, and opposite to its divisions. Ovary free, 1-celled, with a single ovule attached to its base. Fruit a utricle or achene, sometimes succulent. Embryo coiled round mealy albumen, or spiral without albumen. Inconspicuous plants, found in waste places in various parts of the world, chiefly in extra-tropical regions. Many of the plants of this order are used as potherbs, for instance, Spinage, Garden Orach, and Beet. Soda is supplied by some of the species of Salicornia and Salsola growing on the sea-shore. Common Beet (*Beta vulgaris*) is cultivated largely in France for the sake of the sugar procured from its roots. Mangold wurzel (*Beta vulgaris*, var. *campestris*) is used as food for

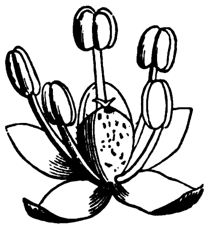


Fig. 430.

Fig. 430.—Flower of Chenopodium, Goosefoot, showing the perianth, consisting of five parts united at the base, five stamens opposite the segments of the perianth, ovary single, superior, with two styles.

cattle. Chenopodium Quinoa is a Peruvian plant, the seeds of which are used as food.

Order POLYGONACEÆ, the Knot-grass Family, includes buckwheat, docks, and rhubarb. All the plants have a calyx and no corolla, a more or less triangular fruit (achene), containing a single erect seed (figs. 431-

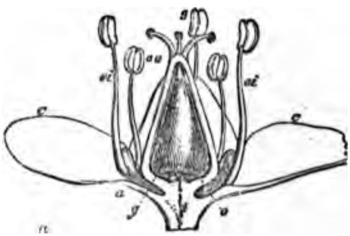


Fig. 431.

Fig. 432.

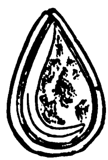


Fig. 433.

433). Buckwheat (*Fagopyrum esculentum*) is extensively cultivated as a kind of grain in many northern countries.

Figs. 431-433.—Organs of reproduction of *Fagopyrum esculentum*, buckwheat, to illustrate the natural order Polygonaceæ.

Fig. 431.—Vertical section of the flower. *c c*, Perianth (calyx). *e e*, Outer stamens, which are introrse. *ei*, Inner stamens, which are extrorse. *a*, Glandular appendages. *o*, Ovary, with its erect ovule, *g*. *s*, Styles and stigmas.

Fig. 432.—Diagram of the flower, showing five divisions of the imbricate perianth; introrse and extrorse stamens in two rows, with glands, and triangular unilocular ovary.

Fig. 433.—Seed cut vertically, showing the embryo with its superior radicle, curved at one side of mealy albumen.

The seed contains a large quantity of mealy albumen, with the embryo lying in a curved form at one side, as shown in the woodcut (fig. 433).

Order Urticaceæ, the Nettle Family, is another Monochlamydeous group (figs. 434-437). The stamens

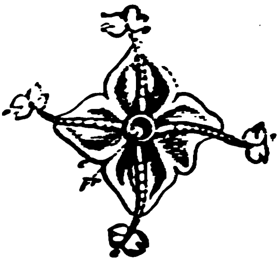


Fig. 434.

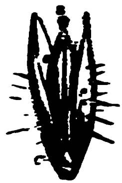


Fig. 435.

Fig. 436.

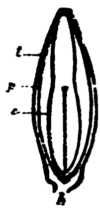


Fig. 437.

Figs. 434-437.—Organs of fructification of *Urtica urens* (small nettle), to illustrate the natural order Urticaceæ.

Fig. 434.—Staminate flower expanded. *c*, Perianth with four divisions. *e e e e*, Four hypogynous stamens, thrown back by the elasticity of the filaments, with the anthers burst. *pr*, Abortive rudiment of the central pistil.

Fig. 435.—Pistillate flower. *c*, Perianth with four unequal segments, the two exterior ones being very small. *o*, Unilocular ovary. *s*, Sessile stigma.

Fig. 436.—Pistil cut vertically, to show the direction of the erect ovule, *o*. *p*, Parietes of the ovary. *s*, Stigma.

Fig. 437.—Seed cut vertically. *t*, Integument. *h*, Hilum or base. *p*, Albumen. *e*, Embryo.

are in one flower (fig. 434) and the pistil in another flower (fig. 435). There are usually four divisions of the calyx (figs. 434; 157, p. 113), and the stamens have frequently elastic filaments (figs. 434; 155, p. 113). The fruit is an achene (fig. 436), and contains an erect seed with an inverted embryo (fig. 437). Some of the plants have stinging hairs (fig. 80, p. 54). One of our native nettles (*Urtica urens*) is monœcious, while another (*Urtica dioica*) is diœcious.

Order AMENTIFERÆ, the Catkin-bearing Family, includes the willow, poplar, oak, hazel, chestnut, birch, beech, etc. They have staminate flowers arranged in catkins, each flower being covered by a scale (figs. 189, p. 137; 190, p. 138). They differ in the character of the ruit. The willows (fig. 191, p. 138) and poplars have a 1-celled fruit opening by 2 valves and containing many hairy seeds, covered by a scale or bract. The hazel, oak, chestnut, and beech, have a dry 1-seeded fruit or nut (figs. 21 5, 216, p. 15), covered by scales.

Other monochlamydeous dicotyledons have their seeds naked—that is, not contained in a seed-vessel, and are included under

Section 2. GYMNOSPERMÆ. — Monochlamydeous or Achlamydeous trees, with an Exogenous structure as regards their stems and organs of vegetation, but differing from other Exogens in having naked ovules, which are fertilized by the direct application of the pollen to the foramen, without the intervention of stigma, style, and ovary.

Order CONIFERÆ, Cone-bearing Family.—In this order are included such plants as fir, spruce, and cedar (fig. 52, p. 31 ; fig. 56, p. 35). They have flowers with stamens only, and others with pistils only. Their seeds, although naked, are covered by hard scales, and collected in cones (fig. 220, p. 155) ; and are sometimes winged (fig. 237, p. 165). In the genus *Pinus*, including the Scotch fir, the stone-pine, the Austrian pine, the Weymouth pine, etc., the leaves are in twos, threes, fours, fives, and sixes, arising from shortened branches. In the Norway spruce (*Abies*) the leaves arise singly from the branches. In the larch (*Larix*) the leaves during the first year arise singly from the young branches, while in the second and future years they appear in clusters on short abortive branches called spurs, and fall off at the end of the season ; in the cedar (*Cedrus*) they are also in clusters, but they are permanent (evergreen). The woody tissue of Conifers is marked by the presence of discs (bordered pits, figs. 49-51, p. 30).

QUESTIONS.

1. Define the sub-class Monochlamydeæ.
2. What is meant by Achlamydeous plants ?
3. Give the characters of the order Chenopodiaceæ.
4. Mention some of the plants of the order.
5. What are the properties of the order ?
6. What plants are included in the Polygonaceæ ?
7. What are the usual characters of their fruit and seed ?
8. What is the usual position of their embryo ?
9. Give some of the characters of Urticaceæ.
10. Mention some plants belonging to the order.
11. What kind of stamens are found in the nettle ?
12. What kind of fruit has the nettle ?

13. Give the characters of Amentiferæ. Example.
14. Give the general character of a catkin (amentum).
15. What kind of fruit and seed is seen in the willow?
16. Describe the fruit of the hazel.
17. Describe the fruit of the oak.
18. Mention a peculiarity in the seed of the poplar.
19. What is meant by Gymnospermous plants? Example.
20. What is the nature of the fruit in Coniferæ?
21. What kind of seeds occur in the common firs?
22. What is the leaf-arrangement in the genus Pinus?
23. How are the leaves of the spruce-fir arranged?
24. How are the leaves of the larch arranged?
25. What is the difference between the larch and the cedar as regards their leaves?
26. What is the character of the wood of conifers? How can it be detected under the microscope?

We now proceed to consider the second great class of the vegetable kingdom.

CLASS II.—MONOCOTYLEDONES, ENDOGENÆ.

In this great class the plants have a *cellular* and *vascular* system, the latter consisting partly of elastic spiral vessels (fig. 11, p. 5). The *stem* is sometimes herbaceous, as in the banana (fig. 13, p. 7). At times it is creeping or subterranean, and assumes the form of a rhizome (figs. 37, 38, p. 24), or of a corm (figs. 40 and 41, p. 25), or of a bulb (fig. 39, p. 25). The woody stem (as in palms, figs. 60, 61, p. 39) is usually more or less cylindrical, simple, and unbranched. There is no true separable bark, no concentric zones, and no true pith (fig. 57, p. 37). The *wood* is endogenous—*i.e.* increases by additions, which first tend towards the centre,

and then curve outwards in an interlacing manner (fig. 58, p. 37) towards the circumference, where much hard ligneous matter is deposited, so as to make the exterior the hardest part (fig. 59, p. 38). The development of the stem usually takes place by a single central and terminal bud; occasionally lateral buds are produced (fig. 28, p. 18), and at times the stem is hollow. The *leaves* are parallel-veined (figs. 13, p. 7; 73 and 74, p. 50). The parts of the *flower* are arranged in a ternary manner (fig. 126, p. 95), and they are often coloured like petals, sometimes scaly. The ovules are contained in an ovary, and are fertilized by the application of the pollen to the stigma. The *embryo* has one cotyledon, and the rootlets pass through sheaths (fig. 243 *co*, p. 172).

SUB-CLASS I.—PETALOIDEÆ.

Flowers having usually a perianth consisting of verticillate leaves, which may sometimes be separated into calyx and corolla, and are often coloured (petaloid).

1. *Perianth superior. Ovary inferior. Flowers usually perfect*—i.e. *having both stamens and pistil.*

Order ORCHIDACEÆ, the Orchis family (figs. 438-440), is one of the most remarkable families in this division of Monocotyledons. The perianth consists of two rows of coloured leaves, three of which are external and three internal, alternating (fig. 192, p. 140). In the inner row there is usually a marked petal called the lip (labellum, fig. 438 *l*; 192 *l*, p. 140). The stamen and pistil are gynandrous—that is, united in one column

(fig. 438 *a s*; 192 *a*, p. 140), and the pollen consists of masses attached by glands, surrounded by viscid matter which enables them to adhere to any object which touches them (fig. 186, p. 136). The seed-vessel has 3 parietal placentas (fig. 201, p. 145), and the seeds are beautifully reticulated (fig. 440), the embryo in the young state being seen through the transparent covering. In the Orchises of Britain the roots have fleshy tuber-

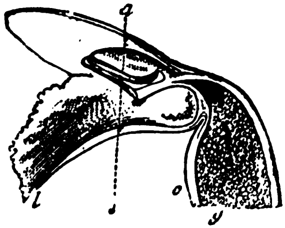


Fig. 438.

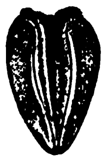


Fig. 439.

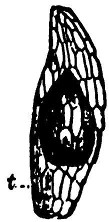


Fig. 440.

cules attached to them (figs. 30, 31, p. 19). In orchideous plants of warm countries there are thickened stems called false-bulbs (fig. 32, p. 20). Many of the latter plants are epiphytic (p. 20).

This order is easily illustrated by the common Orchises of the woods and marshes. The viscidity of the pollen-masses is observed by putting the sharpened end of a common pencil into the opening in the perianth

Figs. 438 to 440.—Flower of *Spiranthes autumnalis*, fragrant lady's tresses, to illustrate the natural order Orchidaceæ.

Fig. 438.—Summit of the flower cut vertically. *o*, Inferior ovary with parietal ovules, *g*. *l*, Labellum or lip. *s*, Stigma. *a*, Anther.

Fig. 439.—Anther separated. Its inner surface shown with its two cells.

Fig. 440.—A seed separated, with its external reticulated integument, *t*.

leading down to the spur (fig. 192 *e*, p. 140), and then withdrawing it. By doing so we find that the pollen-masses adhere to the pencil and are pulled out along with it (see remarks at page 141). The upper and lower parts of the seed-vessels respectively continue adherent, while the capsule opens by splitting into 6 portions. Vanille consists of the dried seed-vessels of an Orchid. For Formulæ of Orchis and Cypripedium, see page 203.

There are two other families in this section of Monocotyledons, which may be put in contrast—the Iris and Amaryllis order.

Order IRIDACEÆ, the Iris Family (figs. 441, 442).—In this order the perianth consists of 6 coloured divisions in two rows (fig. 441), the three parts of the outer row being deflexed in the Iris (fig. 442) ; and three stamens, which open on the outside (extrorsely), are placed behind three petaloid divisions of the style (fig. 442 *g g*). The fruit is inferior (below the perianth, fig. 442 *o*), and constitutes a 3-celled capsule, opening by 3 valves, the slits being at the backs of the cells (loculicidal). The plants have rhizomes, as in the case of orris-root (the creeping stem of the Florentine Iris), or they have corms, as in the crocus (fig. 40, p. 25). Saffron, an orange dye, consists of the upper part of the styles of *Crocus sativus*.

Order AMARYLLIDACEÆ, the Amaryllis Family.—This order differs from the last chiefly in its 6 stamens, with anthers opening on the inner side (introrsely). It is illustrated by the common snowdrop, the snow-

flake (fig. 126, p. 95), the narcissus (fig. 127, p. 96). The plants have usually scaly bulbs under ground.

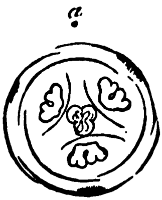


Fig. 441.


Fig. 442.

We now proceed to another section of petaloid monocotyledons, where the ovary is differently placed—

2. *Perianth inferior. Ovary superior. Flowers usually perfect*—i.e. *having both stamens and pistil.*

Under this section we may contrast two orders—

Figs. 441, 442.—Organs of fructification of *Iris germanica*, the common garden Iris, to illustrate the natural order Iridaceæ.

Fig. 441.—Diagram of the flower, showing six divisions of the perianth in two whorls, three extrorse stamens, and a 3-celled capsule with numerous ovules. *a*, Position of the axis of Inflorescence.

Fig. 442.—Vertical section of the flower. *ce*, Outer divisions of the coloured perianth. *ci*, Inner divisions of the perianth. *t*, Tube of the perianth above the part which is adherent to the ovary. *o*, Inferior 3-celled ovary. *g*, Numerous ovules. *e e*, Stamens. *s s*, Petaloid portion of the style with the stigmas.

the lily family and the meadow-saffron family. Rushes and Palms also belong to this section.

Order Liliaceæ, the Lily Family (figs. 443 to 446).—In this order there is a perianth of six divisions in two rows (fig. 443); the stamens are usually six, and have anthers opening on the inside (introrse) (figs. 444, 445).

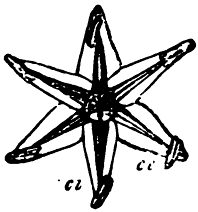


Fig. 443.

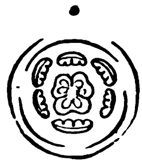


Fig. 444.

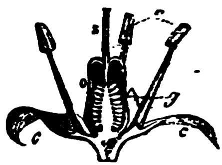


Fig. 445.

The fruit is three-celled (fig. 199, p. 144), and the seeds numerous. Many of the plants have bulbs (fig. 39, p. 25), others have rhizomes (fig. 37, p. 24), while some assume a tree-form, as *Dracæna*, the dragon-tree (fig. 446). The order is illustrated by lilies, leeks, onions, squill, hyacinth, fritillary, tulip, tuberose, and dog-tooth violet. For Formula of Lily, see p. 202.

Order Melanthaceæ or Colchicaceæ, the Meadow-saffron Family. This order differs from the lilies chiefly in having anthers opening on the outside (extrorse).

Figs. 443-445.—Organs of reproduction of *Scilla autumnalis* (autumnal squill), to illustrate the natural order Liliaceæ.

Fig. 443.—Flowers seen from above. *ce*, Outer whorl of the perianth (calyx). *ci*, Inner whorl of the perianth (corolla).

Fig. 444.—Diagram of the flower, showing three outer and three inner leaves of the perianth, six alternating stamens in two rows, and three carpels of the ovary with the ovules.

Fig. 445.—Vertical section of the flower. *c c*, Perianth. *e*, Stamens introrse. *o*, Ovary. *s*, Style and stigmas. *g*, Ovules attached to a placenta in the axis.

It is illustrated by the common meadow-saffron, or autumn-flowering crocus. This plant has underground corms (fig. 41, p. 25).

Order JUNCACEÆ, the Rush Family, is allied to

Fig. 446.

Fig. 447.

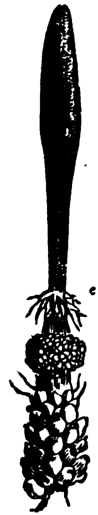


Fig. 448.

these two orders. These plants are often confounded by common observers with sedges (carices) and bul-

Fig. 446.—Dragon-tree (*Dracæna Draco*).

Fig. 447.—Perianth of *Luzula*, one of the Juncaceæ, with 6 divisions of its glumaceous perianth, 6 stamens, pistil with 1 style and 3 stigmas.

Fig. 448.—Spadix of *Arum maculatum*, belonging to natural order Araceæ, removed from its spathe; pistillate flowers *a*, staminate *b*, abortive *c*, fleshy end of spadix *d*.

rushes. They are at once distinguished by examining their flowers, and finding that the perianth consists of six divisions arranged in a whorled manner (fig. 447). The perianth is dry, greenish or brownish.

Order PALMÆ, the Palm Family, is also placed in this section of petaloid Monocotyledons. Their flowers resemble those of the lilies. They are small and arranged in clusters. Palms are well characterised by their stems, leaves, inflorescence, and fruit (figs. 60, 61, p. 39; 73, p. 50; 241, p. 167).

There is another section (3) of petaloid Monocotyledons, in which the flowers are incomplete—that is, they have staminate and pistillate flowers. Moreover, their perianth is imperfect, being sometimes wanting, and at other times consisting of a few scales. Such plants as the cuckoo-pint (*Arum maculatum*) belong to this division (fig. 448). It is placed in the natural order ARACEÆ.

We now come to the concluding sub-class of Monocotyledons—

SUB-CLASS II.—GLUMIFERÆ.

Flowers glumaceous (glumiferous or glume-bearing) consisting of bracts or scales, which are imbricated, and not arranged in true verticils. Leaves with parallel veins. In this sub-class there are two orders—the sedges and the grasses.

Order CYPERACEÆ, the Sedge Family (figs. 449, 450; fig. 12, p. 5). They are grassy plants with solid stems. The sheaths of the leaves are not split (as in grasses).

The flowers have either stamens and pistils, or stamens exist in one flower and pistils in another. The flowers are arranged in spikes or heads. Each flower is covered by a bract, and in the case of some pistillate flowers there is an additional covering. The stamens are usually three, and the fruit is an achene. The little embryo is at the base of albumen, and is not

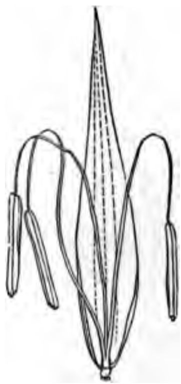


Fig. 449.

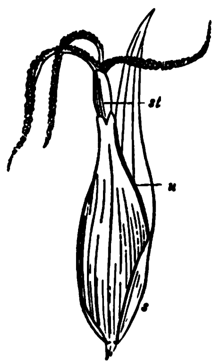


Fig. 450.

placed at one side (as in grasses). The character of the flower is seen in figs. 449 and 450, the former representing a staminate flower with three stamens bearing anthers, which are fixed to the filament by their base (not versatile as in grasses); and the latter representing a

Fig. 449.—Staminate flower of *Carex*, sedge, consisting of a scale or glume bearing 3 stamens with long filaments and innate anthers.

Fig. 450.—Pistillate flower of *Carex*, consisting of a scale or glume, *s*, bearing a pistil surrounded by a special covering, *u*, through which projects the style, *st*, with its three stigmas.

pistillate flower with its outer scales, its additional covering, with the style passing through it, and dividing into three hairy portions bearing stigmas.

Order GRAMINEÆ, the Grass Family (figs. 451-456). This is a large order of plants, and is one of the most important in the vegetable kingdom, whether we regard it as supplying food for man or herbage for animals.

Fig. 451.

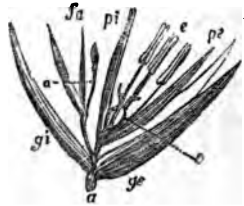


Fig. 452.

The flowers occur commonly in spikelets (figs. 451, 452; fig. 185, p. 136), which are either arranged in a sessile manner along a central axis as in wheat, or are attached to stalks as in oats. The spikelet

Fig. 451-456.—Organs of fructification of *Avena sativa*, common cultivated oat, to illustrate the natural order Gramineæ.

Fig. 451.—Spikelet of the oat. *a*, Axis of inflorescence. *ge*, Exterior or lower glume. *gi*, Inner or upper glume. *ff*, Inferior fertile flower. *fa*, Two upper abortive flowers.

Fig. 452.—The same spikelet with the envelopes separated to show the internal parts. *aa*, Axis of inflorescence. *ge*, Outer glume. *gi*, Inner glume. *pe*, Outer palea of the fertile flower, with its awn (arista). *pi*, Inner palea, cleft at the apex, and apparently formed by two united. *e*, Three stamens. *o*, Pistil, consisting of the ovary and two styles. *fa*, Two abortive flowers.

consists of outer scales called glumes (figs. 451, 452, 453 *ge* and *gi*; fig. 185 *a a*, p. 136). These glumes (bracts or empty glumes) usually enclose several flowers (fig. 185 *b b*, p. 136; fig. 451 *f f* and *fa*). Each of these flowers is composed of two scales called paleæ, the inner one being called by some a fertile glume (fig. 452 *pe* and *pi*). Between the outer and inner paleæ

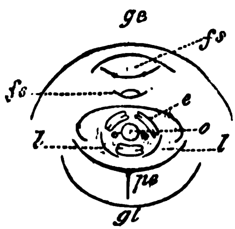


Fig. 453.

Fig. 454.

are situated three stamens (figs. 452 *e*, 454 *e*), which are hypogynous, and have anthers attached at one point to a slender thread-like filament, easily moved by the wind (fig. 185 *s*, p. 136), and at their base scales (called by some perianth), are often placed (fig. 454 *p*). In the centre of the flower is the pistil (454 *o*), consisting of an ovary with 2 styles *s s*, which are feathery at the

Fig. 453.—Diagram of the spikelet of the oat. *ge*, Outer glume. *gi*, Inner empty glume. *pe*, Outer palea (pale) with awn; the inner or fertile palea being opposite. *e*, Stamens. *o*, Pistil. *l l*, Scales or lodiculæ. *fs*, *fs*, Barren flowers.

Fig. 454.—Fertile flower deprived of glumes and paleæ. *e*, Three stamens with versatile cleft anthers. *p*, Scales (squamæ or lodiculæ) partially united. *o*, Ovary ultimately forming the grain, which consists of pericarp and seed combined. *s s*, Two styles with feathery stigmas.

top. The fruit is called a grain (caryopsis), and consists of a single seed closely incorporated with the pericarp, with the embryo lying at one side (fig 455 *e*). This embryo has a single cotyledon (fig. 456 *a*). A diagram of the part of a spikelet is given in the woodcut 453. The leaves of grasses sheath the stem, and the sheaths are split. At the upper part of the sheath there is usually

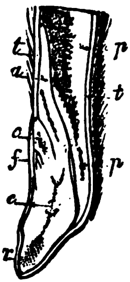


Fig. 455.

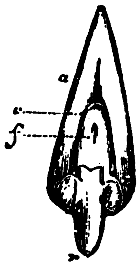


Fig. 456.

seen a process called a ligule. One of the best plants for illustrating this order is the wheat. Of the common native grasses, those most easily examined by a beginner are the brome grasses, some of the larger fescue-grasses, the lyme-grass (*Elymus arenarius*), and the rye-grass (*Lolium perenne*). Among the valuable plants of the order may be mentioned the cereal grains, wheat, oats, barley, rye, rice, maize, millet, the sugar-cane, the bamboo, and the tussac grass.

Fig. 455.—Vertical section of the caryopsis (fruit or grain), with the upper portion cut off. *t t*, Integuments of the caryopsis and of the seed united. *p p*, Perisperm. *e*, Embryo. *r*, Radicle. *c a*, Cotyledon. *f*, Slit corresponding to the plumule.

Fig. 456.—Embryo separated. *r*, Radicle. *c a*, Cotyledon. *f*, Slit corresponding to the plumule.

QUESTIONS.

1. Give the characters of the class Monocotyledones or Endogenæ.
2. Give the characters of the sub-class Petaloideæ.
3. Give the characters of the three sections of Petaloideæ.
4. Give the characters of Orchidaceæ.
5. What is meant by the labellum of orchids?
6. Give the formula for an orchis.
7. In what class of the Linnæan system are orchids placed.
8. What is the character of the pollen of orchids?
9. How does the capsule of orchids open?
10. Give the characters of Iridaceæ.
11. What peculiarity is seen in their style?
12. How do their anthers open?
13. What forms of stems are met with in the Iris and the Crocus?
14. Distinguish between Iridaceæ and Amaryllidaceæ.
15. Give the characters of Liliaceæ. Give the formula.
16. How do the anthers of Liliaceæ open?
17. What kind of subterranean stems occur in Liliaceæ?
18. Give the distinguishing characters between Liliaceæ and Melanthaceæ.
19. Give the essential characters of Juncaceæ.
20. Give the characters of the sub-class Glumiferæ.
21. Give the essential characters of Cyperaceæ.
22. Describe a staminate flower of Carex.
23. Describe a pistillate flower of Carex.
24. Give the essential characters of Gramineæ.
25. What is meant by the glumes of grasses?
26. What is meant by the paleæ of grasses?
27. What is the difference between an empty glume and a flowering glume?
28. Describe a spikelet of a grass.
29. Describe the leaves of grasses.
30. What kind of stigmas are found in grasses?

31. What kind of anther occurs in grasses?
32. What is the nature of the fruit of grasses?
33. What are lodiculæ of grasses?

DIVISION B.—Cryptogamous or Flowerless Plants.

CLASS III.—ACOTYLEDONES.

The plants belonging to this Class are in some instances composed entirely of *cellular tissue;* in other instances both cells and vessels are present. The *vascular tissue* in the higher orders consists partly of scalariform vessels (fig. 9, p. 4). Many of them have no true stem or leaves. The *woody stem,* when present, consists of peculiar vascular bundles, which increase in an acrogenous manner (fig. 64, p. 41). The stem of tree-ferns (which illustrate this class) is unbranched, more or less uniformly cylindrical, hollow in the interior, and marked by the scars of the leaves (fig. 63, p. 41). *Stomata* occur in the epidermis of the higher orders. *Leaves,* when present, have frequently no true venation, at other times the venation is forked. There are no *flowers,* and no distinct stamens or pistils. *Reproduction* takes place by the union of cells of different kinds (antheridia and pistillidia or archegonia) (figs. 255, 256, p. 181), by means of which germinating bodies called *spores* are formed (fig. 249, p. 174). The *spore* may be considered as a cellular embryo, which has no cotyledons, and germinates from any part of its surface.

SUB-CLASS I.—ACROGENÆ.

Acotyledons, having usually distinct stems and leaves, stomata, a certain amount of vascular tissue and *thecæ* or cases containing spores.

Order Filices, the Fern Family (figs. 457-460). Stem,

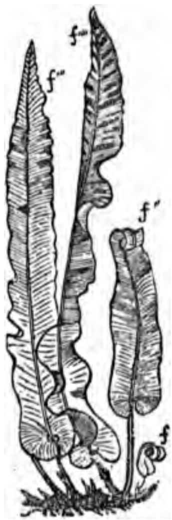


Fig. 457.

Fig. 458.

Fig. 459.

Fig. 460.

Fig. 457.—Rhizome of *Scolopendrium vulgare*, common hart's-tongue, with several fronds (leaves), f', f'', f''', f'''', in different degrees of development. In f' and f'' the circinate vernation is seen. In f'''' the linear transverse sori or clusters of sporangia are seen, having the appearance of dark lines on the lower surface of the frond.

Figs. 458-460.—Frond and fructification of *Polystichum angulare*,—angular-leaved shield fern—to illustrate the natural order Filices.

Fig. 458.—Part of the frond seen on the lower surface. *p*, Two pinnæ covered with sori, *s*, having an indusium. *r*, Rachis or central stalk of the frond.

Fig. 459.—One of the sori or clusters of sporangia cut vertically. *n*, The vein bearing it. *i*, Indusium or fold of the frond covering it. *c*, Thecæ or sporangia (spore-cases).

Fig. 460.—One of the thecæ separated at the period of dehiscence. *a*, Incomplete annulus, or ring, which is elastic, and causes transverse dehiscence of the theca. *p*, Stalk of the theca. *s*, Spores discharged.

either a rhizome (fig. 457), which creeps along or under the surface of the ground, and emits descending roots and ascending fronds (leaves), or an acrogenous trunk which rises into the air (fig. 62, p. 40). This trunk (caudex or stipe) is of nearly uniform diameter, hollow inside, marked on the hard outer rind by the scars (cicatrices) of the leaves (fig. 63, p. 41), and contains vascular bundles of woody, dotted, and scalariform vessels, which are arranged in an irregular manner (fig. 64, p. 41). Sometimes the trunk divides into two, (forks). The leaves (fronds) have a crozier-like (circinate) vernation (fig. 457 *f*); their veins are generally of equal thickness, either simple or dividing in a forked manner (fig. 458), or somewhat reticulated. Reproductive organs consist of spore-cases (thecæ, sporangia) which arise from the veins on the under surface of the fronds (figs. 457 f'''', 458 *s*, 459), or from their margin. Spore-cases are either stalked, with the pedicel passing round them in the form of an elastic ring (fig. 460), or sessile and destitute of a ring. They sometimes arise from the surface of the frond, while at other times they spring from below, having a cuticular covering in the form of an indusium or involucre (figs. 458; 250, p. 179). The clusters of thecæ are called sori (fig. 459). The margin of the frond sometimes is folded so as to cover the thecæ, and at times the frond is, as in the royal fern (fig. 252, p. 180), partially converted into clusters of thecæ. For further particulars in regard to ferns, see pages 178-181.

Ferns abound in moist insular climates. They characterise the New Zealand Flora. They are elegant

frond-bearing plants, occurring largely in the tropical islands, and in mild climates. They sometimes occur in the form of large tree-ferns, fifty to sixty feet high (fig. 62, p. 40), which give a peculiar feature to the landscape.

The generic characters of Ferns are founded on the position and direction of the sori, their covered or uncovered condition, as well as on the venation.

For remarks in regard to plants belonging to the order Musci, the Moss Family, another acrogenous order, see pages 181 and 182.

Sub-Class II.—Thallogenæ or Cellulares.

Acotyledons composed entirely of cellular tissue, having no distinct axis, no true leaves, and no stomata; propagated by means of spores, which are often enclosed in tubes called *asci*.

Under this division are included Lichens, Fungi (the mushroom order), and Algæ (Hydrophyta), or cryptogamic plants found in fresh and in sea water.

For remarks on the character of these orders, see pages 183 to 191.

QUESTIONS.

1. Give the general characters of Cryptogamous plants.
2. What is the nature of their embryo?
3. What is the character of their stems?
4. Describe the sub-class Acrogenæ.
5. Give the characters of the order Filices.
6. How do the stems of Tree-ferns divide?
7. What height do Tree-ferns attain?

8. What is meant by the frond of a fern?
9. What kind of sporangia occurs in ferns?
10. What is meant by the theca of a fern?
11. What is meant by the indusium or involucre of ferns?
12. What kind of vernation occurs in ferns?
13. What kind of vascular tissue occurs in ferns?
14. How are the spores of ferns scattered?
15. What is meant by the sori of ferns?
16. In what climates do ferns abound?
17. Describe the sub-class Thallogenæ or Cellulares.
18. Mention some plants in this sub-class.

We have now given a description of the structure or anatomy of plants, of the forms and arrangement of their various organs—roots, stems, leaves, flowers, fruit, seed, and embryo—along with their functions and uses. We have also explained the systems of artificial and natural classification, illustrating the latter in a special manner by means of several natural orders.

No step can be taken in classification, or in what is called systematic botany, unless the pupil has become fully acquainted with the facts contained in Part I. It is vain to attempt to understand classes, orders, genera, and species, without a thorough knowledge of the organs concerned in classification. When a student takes an unknown flowering plant into his hand, and wishes to make out its place in a system, and to know its relation and affinities, he looks first at the stem or branch, leaves, and flowers; and by the structure, venation, and symmetry of these organs, he can at once refer it to its great class in the natural system. Then, by an examination of the position of the stamens, and of

the perianth, by the presence or absence of the corolla, and by its character when present, he can find the sub-class and the section to which the specimen belongs. The next step is to determine the order. This requires a fuller examination of all the reproductive organs, from the calyx to the embryo. Assistance in ascertaining the order is provided by analytical tables, such as those given in my *Class Book of Botany* (pp. 791, 842, 871, etc.), or in the British floras of Babington, Hooker, and Bentham. The order having been ascertained, the genus is next to be determined. As British plants should be studied in the first instance, the student may have recourse to the floras just mentioned, and in these he will find the characters detailed so as to lead to the determination of the genus and species. The description, however, of plants cannot be comprehended unless the student has a sound foundation of vegetable anatomy, or, as it is called, vegetable organography.

Certain terms are used in the descriptions of plants, and, without a complete understanding of these, it is vain to attempt to follow the characters laid down in botanical works. Strict definitions are required in botany as in all the other natural sciences, and accuracy of description is absolutely necessary. Hence the value of this science in training the mind to observe and discriminate correctly. In studying terms, however irksome it may appear, the student is not losing time. He is acquiring correct ideas as to the structure, forms, arrangements, and development of the various parts of plants; and the lesson which he thus learns

will be of great service to him in after-life. Personal examination of plants in the garden and in the fields is absolutely essential to the student of botany. Thus, his studies, while they train his mental powers, also invigorate his bodily frame, and lead him to take an intelligent and comprehensive view of the plants with which God has clothed the globe, from the minute lichen or moss up to the stately trees of the forest.

GLOSSARY

OR

EXPLANATION OF SOME BOTANICAL TERMS.

Note.—For a full Glossary of Terms, see Balfour's *Botanist's Companion*, 2d Edit. 1875.

A, *alpha*, privative of the Greek, placed before a Greek or Latin word, indicates the absence of the organ; thus, *aphyllus*, leafless; *acaulis*, stemless.

ABNORMAL, deviating from regularity or from the usual form or structure.

ABORTIVE, a part suppressed, depending on non-development.

ACCUMBENT, applied to the embryo of Cruciferæ, when the cotyledons have their edges applied to the folded radicle.

ACHENE or ACHÆNIUM, a monospermal (single-seeded) seed-vessel which does not open, but the pericarp of which is separable from the seed.

ACHLAMYDEOUS, having no floral envelope.

ACICULAR, like a needle in form.

ACOTYLEDONOUS, having no cotyledons.

ACROGEN and ACROGENOUS, increasing at the summit; applied to the stems of ferns, which have a vascular cylinder penetrated by bundles of vessels (scalariform) belonging to the fronds; and stems marked by the scars of the leaves.

ACROS, in composition *acro*, the summit.

ACULEUS, a prickle, a process of the bark (not of the wood), as in the Rose.

ACUMINATE, drawn out into a long point, but with the sides slightly hollowed.

ACUTE, terminating gradually in a sharp point.

ADELPHOUS or ADELPHIA, in composition, means union of the filaments of the stamens.

ADHERENT, united, adhesion of parts that are normally separate, as when the calyx is united to the ovary.

ADNATE, when an organ is united to another throughout its whole length, as the stipules in Rose, and the filament and anther in Ranunculus.

ADVENTITIOUS, organs produced in abnormal positions, as roots arising from aerial stems.

ÆSTIVATION, the arrangement of the parts of the flower in the flower-bud.

AFFINITY, relation in all essential organs.

ALA, a wing, applied to the lateral petals of a papilionaceous flower, and to membranous appendages of the fruit, as in the elm, or of the seed, as in pines.

ALBUMEN, the nutritious matter stored up with the embryo, called also *Perisperm* and *Endosperm*.

ALBURNUM, the outer young wood of a Dicotyledonous stem.

ALTERNATE, arranged at different heights on the same axis, as when each leaf is separated by internodes from those next to it; or opposite

to the spaces between the parts in the next whorl, as in flowers.

AMENTUM, a catkin or deciduous staminate spike; plants having catkins are *Amentiferous*.

AMPLEXICAUL, embracing the stem over a large part of its circumference.

ANASTOMOSIS, union of vessels, forming a kind of network; union of the final ramifications of a leaf.

ANATROPAL or ANATROPOUS, an inverted ovule, the hilum and micropyle being near each other, and the chalaza at the opposite end.

ANDRŒCIUM, the staminal whorl of the flower.

ANEMOPHILOUS, applied to flowers in which pollination is effected by the wind.

ANER, stamen, in composition, *Andro*, *Androus*, and *Andria*.

ANGIOSPERMOUS, having seeds contained in a seed-vessel.

ANNUAL, applied to plants which spring from seed, flower, and die in the same year.

ANNULUS, a ring, applied to the elastic rim surrounding the sporangia of some Ferns; also to a cellular rim on the stalk of the Mushroom, being the remains of the veil.

ANTERIOR, same as *inferior*, when applied to the parts of the flower in their relation to the axis; next the bract or in front.

ANTHER, the part of the stamen containing pollen.

ANTHERIDIUM, staminal organ in Cryptogamic plants, frequently containing moving antherozoids.

ANTHOTAXIS, the arrangement of the flowers on the axes.

APETALOUS, without petals, in other words, monochlamydeous.

APEX, the end farthest from the point of attachment.

APOCARPOUS, ovary and fruit composed of numerous distinct carpels.

APOTHECIUM, the rounded shield-like fructification of Lichens.

ARCHEGONIUM, the young pistilline cellular organ in Cryptogamic plants.

ARIL and ARILLODE, an extra covering of the seed, as in the Passion-flower and Mace.

ARISTA, an awn, a long-pointed process, as in Barley and many Grasses which are called *Aristate*.

ARTICULATED, jointed, separating easily and cleanly at some point.

ASCIDIUM, a pitcher or folded leaf, as in Nepenthes.

ASCUS, a bag, applied to the theca of Lichens and other Cryptogams, containing sporidia or spores.

AWN and AWNED, see *Arista* and *Aristate*.

AXIL, the upper angle where the leaf joins the stem.

AXILLARY, arising from the axil of a leaf.

AXIS is applied to the central portion of the young plant, whence the plumule and radicle are given off, and the name is given in general to the central organ bearing buds.

BACCA, berry, a fruit having a soft outer covering, and seeds immersed in pulp. All such fruits are called *Baccate*.

BARK (cortex), the outer cellular and fibrous covering of the stem; separable from the wood in Dicotyledons.

BASAL or BASILAR, attached to the base of an organ.

BASE, the end nearest to the point of attachment.

BAST or BASS, the inner fibrous bark of Dicotyledonous trees.

BIFID, two-cleft, cut down to near the middle into two parts.

BILOCULAR, having two loculaments.

BIPAROUS, applied to cymose inflorescence when the floral axis ends in a forking or dichotomous manner.

BIPARTITE, cut down to near the base into two parts.

BIPINNATE, a compound leaf, divided twice in a pinnate manner.

BIPINNATIFID, a simple leaf, with lateral divisions extending to near the middle, and which are also similarly divided.

BIPINNATIPARTITE, differing from bipinnatifid in the divisions extending to near the midrib.

BIPOROSE, having two rounded openings.

BIS, twice, in composition *Bi*.

BISERRATE, or duplicate-serrate, when the serratures are themselves serrate.

BITERNATE, a compound leaf divided into three, and each division again divided into three.

BLADE, the lamina or broad part of a leaf, as distinguished from the petiole or stalk.

BLANCHING, see *Etiolation*.

BOLE, the trunk of a tree.

BORDERED PITS, circular depression on pleurenchyma of conifers.
BRACT, a leaf more or less changed in form, from which a flower or flowers proceed; flowers having bracts are called *Bracteated*.
BRACTEOLE or BRACTLET, a small bract at the base of a separate flower in a many-flowered inflorescence.
BULB, an underground bud covered with scales.
BULBIL or BULBLET, separable buds in the axil of leaves, as in some Lilies.

CADUCOUS, falling off very early, as calyx of Poppy.
CÆSPITOSE, growing in tufts.
CALCAR, a spur, a projecting hollow or solid process from the base of an organ, as in the flowers of Larkspur and Snapdragon; such flowers are called *Calcarate* or spurred.
CALCEOLATE, slipper-like, applied to the hollow petals of some Orchids, also to the petals of Calceolaria.
CALYCIFLORÆ, a sub-class of Exogens, having the stamens attached to the calyx.
CALYPTRA, the outer covering of the theca or sporangium of Mosses.
CALYX, the outer envelope of the flower; when there is only one envelope it is the calyx.
CAMBIUM, mucilaginous cells, between the bark and the young wood, or surrounding the vessels.
CAMPANULATE, shaped like a bell, as the flower of Harebell.
CAPITATE, pin-like, having a rounded summit, as some hairs; also growing in heads or close clusters.
CAPITULUM, head of flowers in Compositæ.
CAPSULE, a dry seed-vessel, opening by valves, teeth, pores, or a lid.
CARINA, keel, the two partially united lower petals of papilionaceous flowers.
CARINAL, applied to æstivation when the carina embraces the other parts of the flower.
CARPEL or CARPIDIUM, the leaf forming the pistil. Several carpels may enter into the composition of one pistil.
CARPOPHORE, a stalk bearing the pistil, and raising it above the whorl of the stamens, as in Lychnis.
CARPOS, fruit, in composition *Carpo*.
CARYOPSIS or CARIOPSIS, the monospermal (single-seeded) seed-vessel of Grasses, the pericarp being incorporated with the seed.
CATKIN, same as *Amentum*.
CAUDEX, the stem of Palms and of Tree-ferns.
CAUDICLE, the process supporting a pollen-mass in Orchids.
CAULESCENT, having an evident stem.
CAULIS, an aerial stem.
CELLULOSE, the chemical substance of which the cell-wall is composed.
CENTRIFUGAL, applied to that kind of inflorescence in which the flowers in the centre or at the top open first.
CENTRIPETAL, applied to that kind of inflorescence in which the flowers at the circumference or base open first.
CEREAL, applied to Wheat, Oats, Barley, and other grains.
CHALAZA, the place where the nourishing vessels enter the nucleus of the ovule.
CHLAMYS, covering, applied to the floral envelope; in composition, *Chlamydeous*.
CHLOROPHYLL, the green colouring matter of leaves.
CHLOROS, green; in composition, *Chloro*.
CHROMOGEN and CHROMULE, the colouring matter of flowers.
CICATRICULA, the scar left after the falling of a leaf; also applied to the hilum or base of the seed.
CILIA (Cilium), short stiff hairs fringing the margin of a leaf; also delicate vibratile hairs of moving spores.
CINENCHYMA, laticiferous tissue, formed by vessels which unite and form a sort of network.
CIRCINATE, rolled up like a crozier, as the young fronds of Ferns.
CIRCUMSCISSILE, cut round in a circular manner, such as seed-vessels opening by a lid.
CIRRUS, a tendril, or modified leaf in the form of a twining process; *Cirrose*, having a tendril, or tendril-like.
CLADOPTOSIS, the fall of branches as in Thuia, Taxodium, and Tamarisc.
CLADOS, a branch; in composition, *Clado*.
CLAVATE, club-shaped, becoming gradually thicker towards the top.
CLAW, the narrow base of some petals, corresponding to the petiole of leaves.

CLEFT, divided to about the middle.
CLOVES, applied to young bulbs, as in the Onion.
COCCUS and COCCUM, applied to the single-seeded portions forming the dry elastic fruit of Euphorbiaceæ.
COHERENT, cohesion of parts in the same whorl, such as sepals, petals, stamens, and carpels.
COLEORHIZA, a sheath covering the radicles of a monocotyledonous embryo.
COLUMN, a part in the flower of an Orchid supporting the anthers and stigma, and formed by the union of the styles and filaments.
COMOSE, furnished with hairs, as the seeds of the Willow.
COMPOUND, composed of several parts, as a leaf formed by several separate leaflets, or a pistil formed by several carpels either separate or combined.
COMPRESSED, flattened laterally or lengthwise.
CONCEPTACLE, a hollow sac containing a tuft or cluster of spores.
CONDUPLICATE, folded upon itself; applied to leaves and cotyledons.
CONE, a dry multiple fruit, formed by bracts covering naked seeds or ovaries.
CONFLUENT, applied to compound fruits formed by several flowers, as Pine-apple and Bread-fruit.
CONJUGATION, union of two cells, so as to develop a spore.
CONNATE, when parts are united even in the early state of development; applied to two leaves united by their bases.
CONNECTIVE, the part which connects the anther lobes.
CONNIVENT, when two organs, as petals, arch over so as to meet above.
CONVOLUTE, when a leaf in the bud is rolled upon itself.
CORD, the process which attaches the seed to the placenta.
CORDATE, heart-shaped, a plane body with the two lobes or broad part of the heart next the stalk or stem; *Cordate-based* leaf is of any shape, but has two lobes at the base.
CORIACEOUS, having a leathery consistence.
CORM, thickened underground stem, as in the Colchicum and Arum.
COROLLA, the inner envelope of the flower.
COROLLIFLORÆ, Gamopetalous Exogens, with hypogynous stamens.
CORONA, a coronal appendage, as the crown of the Daffodil.
CORTEX, the bark; *Cortical*, belonging to the bark; *Corticated*, having a bark.
CORYMB, a raceme in which the lower stalks are longest, and all the flowers come nearly to a level above; *Corymbiferous* or *Corymbose*, bearing a corymb, or in the form of a corymb.
COSTA, a rib, applied to the prominent bundles of vessels in the leaves; *Costate*, provided with ribs.
COTYLEDON, the temporary leaf or lobe of the embryo.
CREMOCARP, the fruit of Umbelliferæ, composed of two separable achenes or mericarps.
CRENATE, having superficial rounded marginal divisions.
CROWN OF THE ROOT, the short stem which is at the upper part of the root of perennial herbs.
CRUCIFORM and CRUCIATE, arranged like the parts of a cross, as flowers of Cruciferæ.
CRYPTOGAMOUS, organs of reproduction obscure.
CRYPTOS, inconspicuous or concealed, in composition *Crypto*.
CULM, stem or stalk of grasses.
CUNEIFORM or CUNEATE, shaped like a wedge standing upon its point.
CUPULA, the cup of the acorn, formed by aggregated bracts.
CUTICLE, the thin layer that covers the epidermis.
CYCLOSIS, movement of the latex in laticiferous vessels.
CYME, a kind of definite inflorescence, in which the flowers are in racemes, corymbs, or umbels, the successive central flowers expanding first; *Cymose*, inflorescence in the form of a cyme.
CYTOGENESIS, cell-development.
CYTOS, a cell, in composition *Cyto*.

DECA, ten, in Greek words, same as the Latin *Decem;* as *decandrous*, having ten stamens; *decagynous*, having ten styles.
DECIDUOUS, falling off after performing its functions for a limited time, as calyx of Ranunculus.
DECIDUOUS TREES, which lose their leaves annually.

DECUMBENT, lying flat along the ground, and rising from it at the apex.

DECURRENT, leaves which are attached along the side of a stem below their point of insertion. Such stems are often called *Winged.*

DECUSSATE, opposite leaves crossing each other in pairs at right angles.

DEFINITE, applied to inflorescence when it ends in a single flower, and the expansion of the flowers is centrifugal; also when the number of the parts of an organ is limited, as when the stamens are under twenty.

DEFOLIATION, the fall of the leaves.

DEGENERATION, when an organ is changed from its usual appearance and becomes less highly developed, as when scales take the place of leaves.

DEHISCENCE, mode of opening of an organ, as of the seed-vessel and anther.

DENTATE, toothed, having short triangular divisions of the margin. The term is also applied to the superficial divisions of a gamosepalous calyx and a gamopetalous corolla.

DENTICULATE, finely toothed, having small tooth-like projections along the margin.

DEPRESSED, flattening of a solid organ from above downwards.

DETERMINATE, applied to definite or cymose inflorescence.

DIACHÆNIUM, same as *Cremocarp*, fruit composed of two achenes.

DIADELPHOUS, stamens in two bundles, united by their filaments.

DIALYSES, separation of parts of a whorl; and *Dilalypetalous*, separate petals.

DICHASIUM, or DICHASIAL INFLORESCENCE, a form of definite inflorescence, when each primary axis produces a pair of opposite, or nearly opposite lateral axes, each of which produces in turn pairs of similar axes.

DICHLAMYDEOUS, having calyx and corolla.

DICHOTOMOUS, forking stem, or axis, dividing by twos, as in Lycopods.

DICLINOUS, staminate and pistillate flowers on the same or separate plants (monœcious or diœcious).

DICOTYLEDONOUS, embryo having two cotyledons.

DIDYNAMOUS, two long and two short stamens.

DIGITATE, compound leaf composed of several leaflets attached to one point.

DIGYNOUS, having two styles.

DIMEROUS, composed of two pieces.

DIMORPHIC, having two forms of flowers, differing in the size and development of the stamens and pistils as in Primrose.

DIŒCIOUS, or DIOICOUS, staminiferous and pistilliferous flowers on separate plants.

DIPLOS, double, in composition *Diplo.*

DIPLOSTEMONOUS, having a double row of stamens.

DIS, twice in composition, *Di*, same as Latin *Bis* or *Bi*; as *disepalous*, having two sepals; *dispermous*, two-seeded.

DISCOID, applied to the tubular flowers of Compositæ.

DISCS, the peculiar rounded and dotted markings on coniferous wood.

DISK, a part intervening between the stamens and the pistil in the form of scales, a ring, etc.

DISPERMOUS, having two seeds.

DISSECTED, cut into a number of narrow divisions.

DISSEPIMENT, a division in the ovary; *true*, when formed by the edges of the carpels; *false*, when formed otherwise.

DISTICHOUS, in two rows, on opposite sides of a stem.

DITHECAL, having two loculaments.

DODECA, twelve; in Latin, *Duodecim.*

DODECAGYNOUS, having twelve styles.

DODECANDROUS, having twelve stamens.

DORSAL, applied to the suture of the carpel which is farthest from the axis.

DORSIFEROUS, Ferns bearing fructification on the back of their fronds.

DORSUM, the back, the part of the carpel which is farthest from the axis.

DOUBLE FLOWER, when the organs of reproduction are converted into petals.

DRUPE, a fleshy fruit like the Cherry, having a stony endocarp. *Drupels*, small drupes aggregated to form a fruit, as in the Raspberry.

DURAMEN, heart-wood of Dicotyledonous trees.

DYNAMIS, power, in composition means superiority in length; as *didynamous*, two stamens longer than two others.

E or EX, in composition corresponds to *alpha*, privative; as *ebracteated*, without bracts; *exaristate*, without awns; *edentate*, without teeth; *ecostate*, without ribs.

ELATERS, spiral filament in the spore-cases of Liverwort.

ELLIPTICAL, having the form of an ellipse; oval, but acute at each end.

EMARGINATE, with a superficial portion taken out of the end.

EMBRYO, the young plant contained in the seed.

EMBRYOGENY, the development of the embryo in the ovule.

EMBRYOLOGY, the study of the formation of the embryo.

EMBRYO-SAC, the cellular bag in which the embryo is formed.

ENDECA, in Greek, eleven; in Latin, *Undecim.*

ENDECAGYNOUS, having eleven styles.

ENDECANDROUS, having eleven stamens.

ENDOCARP, the inner layer of the pericarp next the seed.

ENDOCHROME, the colouring matter of cellular plants.

ENDOGEN, an inward grower, having an endogenous stem; same as Monocotyledon.

ENDON, within or inwards, in composition *Endo.*

ENDOPHLŒUM, the inner bark or liber.

ENDOPLEURA, the inner coat of the seed.

ENDORHIZAL, numerous rootlets, arising from a common radicle, and passing through sheaths, as in endogenous germination.

ENDOSMOSE, movement of fluids inwards through a membrane.

ENDOSTOME, the inner foramen of the ovule.

ENDOTHECIUM, the inner coat of the anther.

ENNEA, nine; in Latin, *Novem.*

ENNEAGYNOUS, having nine styles.

ENNEANDROUS, having nine stamens.

ENTIRE (*integer*), without marginal divisions; (*integerrimus*), without either lobes or marginal divisions.

ENTOMOPHILOUS, applied to flowers in which pollination is effected by insects.

ENVELOPES, FLORAL, the calyx and corolla.

EPI, upon, in composition means on the outside or above, as *epicarp*, the outer covering of the fruit; *epigynous*, above the ovary.

EPICALYX, outer calyx, formed either of sepals or bracts, as in Mallow and Potentilla.

EPICARP, the outer covering of the fruit.

EPIDERMIS, the cellular layer covering the external surface of plants.

EPIGYNOUS, above the ovary.

EPIPHYTE, attached to another plant, and growing suspended in the air.

EPISPERM, the outer coat of the seed.

EQUITANT, applied to leaves folded longitudinally, and overlapping each other without any involution.

ERECT, applied to an ovule which rises from the base of the ovary; also applied to innate anthers.

ETÆRIO, aggregate drupes forming the fruit of the Bramble.

ETIOLATION, blanching, losing colour in the dark.

EXALBUMINOUS, without a separate store of albumen or perisperm.

EXANNULATE, without a ring, applied to some Ferns.

EXCURRENT, running out beyond the edge or point.

EXO, in composition, on the outside.

EXOGEN, outward-grower, having an Exogenous stem, same as Dicotyledon.

EXORHIZAL, radicle proceeding directly from the axis, and afterwards branching, as in Exogens.

EXOSMOSE, the passing outwards of a fluid through a membrane.

EXOSTOME, the outer opening of the ovule.

EXSERTED, extending beyond an organ, as stamens beyond the corolla.

EXSTIPULATE, without stipules.

EXTINE, the outer covering of the pollen-grain.

EXTRORSE, applied to anthers which open on the side farthest removed from the pistil.

FASCICLE, a shortened umbellate cyme, as in some species of Dianthus (pink).

FASCICULATE, similar parts springing in a bundle from one point.
FEATHER-VEINED, a leaf having the veins passing from the midrib at a more or less acute angle, and extending to the margin.
FERTILE, applied to pistillate flowers; and to the fruit-bearing frond of Ferns.
FIBRO-CELLULAR tissue, composed of spiral cells.
FIBROUS, composed of numerous fibres, as some roots.
FIBRO-VASCULAR TISSUE, composed of vessels containing spiral and other fibres.
FID, in composition, cleft, cut down to about the middle.
FILAMENT, stalk supporting the anther.
FILIFORM, like a thread.
FIMBRIATED, fringed at the margin.
FLABELLIFORM, fan-shaped, as the leaves of some Palms.
FLAGELLUM, a runner, a weak creeping stem bearing rooting buds at different points, as in the Strawberry.
FLORAL ENVELOPES, the calyx and corolla.
FOLIATION, the development of leaves.
FOLLICLE, a fruit formed by a single carpel, dehiscing by one suture, which is usually the ventral.
FORAMEN, the opening in the coverings or coats of the ovule.
FOVILLA, minute granular matter in the pollen grain.
FROND, the leaf-like organ of Ferns bearing the fructification; also applied to the thallus of many Cryptogamic plants.
FRUSTULES, the parts or fragments into which Diatoms separate.
FRUTEX, a shrub.
FRUTICOSE, shrubby.
FUGACIOUS, evanescent, falling off early, as the petals of Cistus.
FUNICULUS, the cord connecting the hilum of the ovule to the placenta.
FUNNEL-SHAPED, see *Infundibuliform.*
FURCATE, divided into two branches like a two-pronged fork.
FUSIFORM, shaped like a spindle.

GALEA, applied to a sepal or petal shaped like a helmet; the part is called *Galeate.*
GAMO, in composition, means union of parts.
GAMOPETALOUS, same as *Monopetalous*, petals united.
GAMOSEPALOUS same as *Monosepalous*, sepals united.
GEMMA, a leaf-bud; *Gemmation*, the development of leaf-buds.
GEMMULE, same as *Plumule*, the first bud of the embryo.
GENICULATE, bent like a knee.
GERMEN, same as ovary.
GERMINAL VESICLE, a cell contained in the embryo sac, from which the embryo is developed.
GERMINATION, the sprouting of the young plant.
GIBBOUS, swollen at the base, or having a distinct swelling at some part of the surface.
GLABROUS, smooth, without hairs.
GLAND, an organ of secretion consisting of cells, and generally occurring on the epidermis of plants.
GLANDULAR HAIRS, hairs tipped with a gland, as in Drosera and Chinese Primrose.
GLANS, nut, applied to the Acorn and Hazel-nut, which are enclosed in bracts.
GLAUCOUS, covered with a pale-green bloom.
GLOBULE, the antheridium of Chara.
GLUME, a bract covering the organs of reproduction in the spikelets of Grasses, which are hence called *Glumiferous.*
GLUMELLE and GLUMELLULE, a name applied to the palea or pale of a Grass.
GRAIN, caryopsis, the fruit of Cereal Grasses.
GRAINS of pollen, minute cells composing the pollen.
GYMNOS, naked; in composition *Gymno.*
GYMNOSPERMOUS, plants with naked seeds, *i.e.* seeds not in a true ovary, as Conifers.
GYNANDROUS, stamen and pistil united in a common column, as in Orchids.
GYNE, pistil, and GYN, GYNOUS, and GYNO, in composition, refer to the pistil or the ovary.
GYNOPHORE, a stalk supporting the ovary.
GYRATE, same as *Circinate.*
GYRATION, same as *Rotation* in cells.

HASTATE, halbert-shaped, applied to

a leaf with two portions at the base projecting more or less completely at right angles to the blade.

HEAD. See *Capitulum*.

HEART-WOOD, same as *Duramen*.

HELICOIDAL, having a coiled appearance like the shell of a snail, applied to inflorescence.

HELMET, the upper petaloid sepal of Aconitum.

HEMI, half; same as Latin *Semi*.

HEMICARP, one of the achenes forming the fruit of Umbelliferæ.

HEPTA, seven; same as Latin *Septem*.

HEPTAGYNOUS, having seven styles.

HEPTANDROUS, having seven stamens.

HERB, a plant with an annual stem, opposed to a woody plant.

HERBACEOUS, green succulent plants, which die down to the ground in winter; annual shoots; green-coloured cellular parts.

HETERORHIZAL, rootlets proceeding from various points of a spore during germination.

HEXA, six; same as Latin *Sex*.

HEXAGYNOUS, having six styles.

HEXANDROUS, having six stamens.

HILUM, the base of the seed to which the placenta is attached, either directly or by means of a cord. The term is also applied to the mark at one end of some grains of starch.

HIRSUTE, covered with long stiff hairs.

HISPID, covered with long very harsh hairs.

HISTOLOGY, the study of microscopic tissues.

HOARY, covered with greyish-white down.

HYBRID, a plant resulting from the fertilisation of one species by another.

HYMENIUM, the part which bears the fructification in Agarics.

HYPO, under or below; in composition, *Hyp*.

HYPOCRATERIFORM, shaped like a salver, as corolla of Primrose.

HYPOGYNOUS, inserted below the ovary or pistil.

ICOSANDRIA, having twenty stamens or more, inserted on the calyx; *Icosandrous*, having twenty stamens.

ICOSI, twenty; in composition *Icos*. Same as Latin *Viginti*.

IMBRICATE or IMBRICATED, parts overlying each other like tiles on a house. *Imbricated æstivation*, the parts of the flower-bud alternately overlapping each other, and arranged in a spiral manner.

IMPARI-PINNATE, unequally pinnate, pinnate leaf ending in an odd leaflet.

INCUMBENT, cotyledons with the radicle folded on their back.

INDEFINITE, applied to inflorescence with centripetal expansion; also to stamens above twenty, and to ovules and seeds when very numerous.

INDEHISCENT, not opening; having no regular line of suture.

INDETERMINATE, applied to indefinite inflorescence.

INDIGENOUS, an aboriginal native in a country.

INDUPLICATE, edges of the sepals or petals turned slightly inwards in æstivation.

INDUSIUM, epidermal covering of the fructification in some Ferns.

INFERIOR, applied to the ovary when it is situated below the calyx; and to the part of a flower farthest from the axis.

INFLORESCENCE, the mode in which the flowers are arranged on the axis.

INFUNDIBULIFORM, in shape like a funnel, as seen in some gamopetalous corollas.

INNATE, applied to anthers when attached to the top of the filament.

INSERTED, growing upon.

INTERNODE, the portion of the stem between two nodes or leaf-buds.

INTERPETIOLAR, between the petioles of opposite leaves; as the stipules of Cinchona.

INTERRUPTEDLY-PINNATE, a pinnate leaf in which pairs of small pinnæ occur between the larger pairs.

INTINE, the inner covering of the pollen-grain.

INTRORSE, applied to anthers which open on the side next the pistil.

INVERTED or INVERSE, applied to the embryo when the radicle is directed to a point at the opposite end of the seed from the hilum.

INVOLUCEL, bracts surrounding the partial umbel in Umbelliferæ.

INVOLUCRE, bracts surrounding the general umbel in Umbelliferæ, the heads of flowers in Compositæ, and in general any verticillate bracts surrounding numerous

flowers. Also applied to the Indusium of Ferns.

Involute, edges of leaves rolled inwards spirally on each side, in æstivation.

Irregular, a flower in which the parts of any of the verticils differ in size.

Isomerous, when the whorls of the flower are each composed of an equal number of parts.

Isostemonous, when the stamens are the same in number as the floral envelopes.

Joinings, the places where the parts of the stem are attached to each other; the nodes.

Joints, the spaces between the joinings, nodes, or knots; the parts joined.

Jugum, a pair of leaflets; *jugate*, applied to the pairs of leaflets in compound leaves; *unijugate*, one pair; *bijugate*, two pairs, and so on.

Keel, same as *Carina*.

Kneed, see *Geniculate*.

Knots in trees, formed by abortive branches.

Labellum, lip, one of the divisions of the inner whorl of the flower of Orchids. This part is in reality superior, but becomes inferior by the twisting of the ovary.

Labiate, lipped, applied to irregular gamopetalous flowers, with an upper and under portion separated more or less by a hiatus or gap.

Laciniate, irregularly cut into narrow segments.

Lacuna, a large space in the midst of a group of cells.

Lamellæ, gills of an Agaric, also applied to flat divisions of the stigma.

Lamina, the blade of the leaf, the broad part of a petal or sepal.

Lanceolate, narrowly elliptical, tapering to each end.

Lateral, arising from the side of the axis, not terminal.

Latex, granular fluid contained in laticiferous vessels.

Laticiferous, vessels containing latex which unite together, and form a sort of network.

Latiseptæ, Cruciferous plants having a broad replum in their silicula.

Leaflets, the subdivisions of compound leaves.

Legume, a pod composed of one carpel, opening usually by ventral and dorsal suture, as in Pea.

Lenticel, a small process on the bark of Willows and other plants, whence adventitious roots proceed.

Lenticular, in the form of a double convex lens.

Liber, the fibrous inner bark or endophlœum.

Lignin, woody matter which thickens the cell-walls.

Ligulate, strap-shaped florets, as in Dandelion.

Ligule, a process arising from the petiole of grasses where it joins the blade.

Liguliforæ, Composite plants having ligulate florets.

Limb, the blade of the leaf; the broad part of a petal or sepal; when sepals or petals are united, the combined broad parts are denominated collectively the limb.

Linear, very narrow leaves, in which the length exceeds greatly the breadth.

Lobe, large division of a leaf or any other organ; applied often to the divisions of the anther.

Loculicidal, fruit dehiscing through the back of the carpels.

Loculus or **Loculament**, a cavity in an ovary, which is called *unilocular* when it has one cavity, *bilocular* with two, and so on. The term are also applied to the anther.

Locusta, a spikelet of grasses formed of one or several flowers.

Lodicule, a scale at the base of the ovary of Grasses.

Lomentum and **Lomentaceous**, applied to a legume or pod with transverse partitions, each division containing one seed.

Lyrate, a pinnatifid leaf with a large terminal lobe, and smaller ones as we approach the petiole.

Macros, large, in composition *Macro*.

Macrospores, large spores of Lycopods.

Marcescent, withering, but not falling off until the part bearing it is perfected.

Masked, same as *Personate.*]

Mattulla, the fibrous matter covering the petioles of Palms.

Medulla, the cellular pith.

MEDULLARY RAYS or PLATES, cellular prolongations uniting the pith and the bark.
MEDULLARY SHEATH, sheath containing spiral vessels surrounding the pith in Exogens.
MEMBRANE, the wall of a cell, or a thin covering formed by flattened cells.
MEMBRANOUS, having the consistence, structure, and aspect of a membrane.
MERICARP, single-seeded dry carpel separating from a compound fruit, as in Umbelliferæ and Labiatæ.
MESOCARP, middle covering of the fruit.
MESOSPERM, inner covering of the seed.
MESOPHLŒUM, middle layer of bark.
MESOS, the middle, in composition *Meso.*
MICROPYLE, the opening or foramen of the seed.
MICROSPORE, small spore of Lycopods.
MICROS, small, in composition *Micro.*
MONADELPHOUS, stamens united into one bundle by union of their filaments.
MONANDROUS, having one stamen.
MONILIFORM, beaded, cells united, with interruptions, so as to resemble a string of beads.
MONOCHLAMYDEOUS, flower having a single envelope, which is the calyx.
MONOCOTYLEDONOUS, having one cotyledon in the embryo.
MONŒCIOUS, stamens and pistils in different flowers on the same plant.
MONOGYNŒCIAL, simple fruits formed by the gynœcium of one flower.
MONOGYNOUS, having one pistil or carpel; also applied to plants having one style.
MONOPETALOUS, same as *Gamopetalous.*
MONOS, one, in composition *Mono* and *Mon*, as *Monandrous*, one stamen; sometimes applied to the union of parts into one, as *Monopetalous*, meaning combined petals; same as Latin *Unus.*
MONOSEPALOUS, same as *Gamosepalous.*
MONOSPERMOUS or MONOSPERMAL, having a single seed.
MORPHOLOGY, the study of the forms which the different organs assume, and the laws that regulate their changes.
MUCRO, a stiff point abruptly terminating an organ; *Mucronate*, having a mucro.
MULTICOSTATE, many-ribbed.
MULTIFID, applied to a simple leaf divided laterally to about the middle into numerous portions; when the divisions extend deeper it is *Multipartite.*
MULTILOCULAR, having many loculaments.
MULTIPLE, applied to confluent fruits, such as the Pine-apple.
MURIFORM, like bricks in a wall; applied to cells, chiefly in the Medullary rays.
MUSCI, the natural order of Mosses.
MYCELIUM, the cellular under-ground stem or spawn of Fungi.

NAKED, applied to seeds not contained in a true ovary; also to flowers without any floral envelopes.
NECTARY, any abnormal part of a flower. It ought to be restricted to organs secreting a honey-like matter, as in Crown Imperial.
NETTED, applied to reticulated venation.
NODE, the part of the stem from which a leaf-bud proceeds.
NOTORHIZEÆ, radicle on the back of the cotyledons, as in some Cruciferæ.
NUCLEUS, the body which gives origin to new cells; also applied to the central cellular portion of the ovule and seed.
NUCULE, archegonium of Chara.
NUCUMENTACEOUS, Cruciferæ having a dry monospermal fruit.
NUT, properly applied to the glans; but also applied to any hard nutlike fruit, as in Carex and Rumex.

OB, in composition, means reversed or contrariwise.
OBCORDATE, inversely heart-shaped, with the divisions of the heart at the opposite end from the stalk.
OBLONG, about $\frac{3}{4}$ as long as broad; elliptical, obtuse at each end.
OBOVATE, reversely ovate, the broad part of the egg being uppermost.
OBSOLETE, imperfectly developed or abortive: applied to the calyx when it is in the form of a rim.

OBTUSE, not pointed, with a rounded or blunt termination.
OCTANDROUS, having eight stamens.
OCTO, eight, in composition *Oct.*
OCTOGYNOUS, having eight styles.
ŒCIUM, and ŒCIOUS, and OICOUS, in composition, have reference to the position of the reproductive organs, as *Andrœcium*, the staminal organs; *Diœcious*, or *Dioicous*, stamen and pistil in different plants.
OPERCULUM, lid, applied to the separable part of the theca of Mosses; also applied to the lid of certain seed-vessels; *Operculate*, opening by a lid.
OPPOSITE, applied to leaves placed on opposite sides of a stem at the same level.
ORBICULAR, rounded leaf with petiole attached to the centre of it.
ORGANOGRAPHY, the description of the organs of plants.
ORTHOPLOCEÆ, Cruciferæ having conduplicate cotyledons.
ORTHOS, straight; in composition *Ortho*, same as Latin *Rectus*.
ORTHOTROPAL and ORTHOTROPOUS, ovule with foramen opposite to the hilum; embryo with radicle next the hilum.
OSMOSE, the force with which fluids pass through membranes in experiments on exosmose and endosmose.
OVAL, elliptical, blunt at each end.
OVARY, the part of the pistil which contains the ovules.
OVATE, shaped like an egg, applied to a leaf with the broader end of the egg next the petiole or axis; *Ovate-lanceolate*, a lanceolate leaf, which is somewhat ovate.
OVULE, the young seed contained in the ovary.

PALATE, the projecting portion of the under lip of personate flowers.
PALEA or PALE, the part of the flower of Grasses within the glume; also applied to the small scaly laminæ which occur on the receptacle of some Compositæ.
PALMATE and PALMATIFID, applied to a leaf with radiating venation, divided into lobes to about the middle.
PALMATIPARTITE, applied to a leaf with radiating venation, cut nearly to the base in a palmate manner.
PANICLE, inflorescence of Grasses, consisting of spikelets on long peduncles coming off in a racemose manner.
PAPILIONACEOUS, corolla composed of vexillum, two alæ, and carina, as in a Pea.
PAPPUS, the hairs at the summit of the ovary in Compositæ. They consist of the altered calycine limb. *Pappose*, provided with pappus.
PARAPHYSES, filaments, sometimes articulated, occurring in the fructification of Mosses and other Cryptogams.
PARASITE, attached to another plant, and deriving nourishment from it.
PARENCHYMA, cellular tissue.
PARIETAL, applied to placentas on the wall of the ovary.
PARI-PINNATE, a compound pinnate leaf, ending in two leaflets.
PARTITE or PARTED, cut down to near the base, the divisions being called *Partitions*.
PECTINATE, divided laterally into narrow segments, like the teeth of a comb.
PEDATE and PEDATIFID, a palmate leaf of three lobes, the lateral lobes bearing other equally large lobes on the edges next the middle lobe.
PEDICEL, the stalk supporting a single flower; such a flower is *Pedicellate*.
PEDUNCLE, the general flower-stalk or floral axis. Sometimes it bears one flower, at other times it bears several sessile or pedicellate flowers.
PELTATE, shield-like, fixed to the stalk by a point within the margin; *peltate hairs*, attached by their middle.
PENDULOUS, applied to ovules which are hung from the upper part of the ovary.
PENICILLATE, pencilled, applied to a tufted stigma resembling a camel-hair pencil, as in the Nettle.
PENTA, PENTE, five; same as *Quinque* in Latin.
PENTAGYNOUS, having five styles.
PENTAMEROUS, composed of five parts; a pentamerous flower has its different whorls in five, or multiples of that number.
PENTANDROUS, having five stamens.
PEPO and PEPONIDA, the fruit of the Melon, Cucumber, and other Cucurbitaceæ.
PER, when placed before an adjective, sometimes gives it the value

of a superlative, as *perpusillus*, very weak: at other times it means through, as *perfoliate*, through the leaf.

PERENNIAL, living, or rather flowering, for several years.

PERFOLIATE, a leaf with the lobes at the base, united on the side of the stem opposite the blade, so that the stalk appears to pass through the leaf.

PERI, around: in Latin, *Circa*.

PERIANTH, a general name for the floral envelope; applied in cases where there is only a calyx, or where the calyx and corolla are alike.

PERICARP, the covering of the fruit.

PERIGONE, same as Perianth. Some restrict the term to cases in which the flower is pistilliferous. It has also been applied to the involucre of Jungermannieæ.

PERIGYNOUS, applied to corolla and stamens when attached to the calyx.

PERISPERM, same as albumen of seed.

PERISTOME, the opening in the sporangium of Mosses after the removal of the calyptra and operculum.

PERSISTENT, not falling off, remaining attached to the axis until the part which bears it is matured.

PERSONATE, a gamopetalous irregular corolla having the lower lip pushed upwards, so as to close the hiatus between the two lips.

PETALOID, like a petal.

PETALS, the leaves forming the coralline whorl.

PETIOLATE, having a stalk or petiole.

PETIOLE, a leaf-stalk; *Petiolule*, the stalk of a leaflet in a compound leaf.

PHÆNOGAMOUS, same as *Phanerogamous*.

PHANEROGAMOUS, having conspicuous flowers.

PHANEROS and PHÆNOS, conspicuous; in composition, *Phanero* and *Phæno*.

PHLŒUM, a name applied in composition to the bark.

PHLOEM, the bast portion of a fibro-vascular bundle forming the bark.

PHORUS, PHORUM, and PHORE, in words derived from the Greek, are used as terminations, meaning that which bears; equivalent to the Latin *Ferus* and *Fer*.

PHRAGMA, transverse division or false dissepiment in fruits.

PHYLLARIES, the leaflets forming the involucre of Composite flowers.

PHYLLODIUM, leaf-stalk enlarged so as to have the appearance of a leaf.

PHYLLOID, like a leaf.

PHYLLOPTOSIS, defoliation, or the fall of the leaf.

PHYLLOTAXIS, the arrangement of the leaves on the axis.

PHYLLUM, leaf, in composition *Phyllo* and *Phyllous*; in Latin *Folium*.

PHYSIOLOGY, Vegetable, the study of the functions of plants.

PHYTOZOA, moving filaments in the antheridia of Cryptogams.

PILEORHIZA, a covering of the root, as in Lemna.

PILEUS, the cap-like portion of the Mushroom, bearing the hymenium on its under side.

PILOSE, provided with hairs; such as pappus.

PIN-EYED, flower with long styles, the stigma being visible at the top of the floral tube, as in Primula.

PINNA, the leaflet of a pinnate leaf.

PINNATE, a compound leaf having leaflets arranged on each side of a central rib.

PINNATIFID, a simple leaf cut into lateral segments to about the middle.

PINNATIPARTITE, a simple leaf cut into lateral segments, the divisions extending nearly to the central rib.

PINNULE, the small pinna of a bipinnate or tripinnate leaf.

PISTIL, the central or ovule-bearing organ of the flower, composed of one or more carpels; each carpel being composed of ovary, style, and stigma.

PISTILLATE, and PISTILLIFEROUS, applied to a flower or a plant having a pistil and no stamen.

PISTILLIDIUM, the pistilline organ in Cryptogams.

PITH, the column of cellular tissue in the centre of dicotyledonous stems or branches.

PITTED, covered with small depressed spots.

PLACENTA, the cellular part of the carpel bearing the ovule.

PLACENTATION, the formation and arrangement of the placenta.

PLEURENCHYMA, woody tissue.

PLEURORHIZEÆ, Cruciferous plants having the radicle of the embryo applied to the edges of the cotyledons, which are called *Accumbent*.

PLICATE, plaited or folded like a fan.
PLUMULE, the first bud of the embryo, usually enclosed by the cotyledons.
POD, *see* Legume and Siliqua.
PODOGYNIUM, a stalk supporting an ovary.
POLLARD-TREES, cut down so as to leave only the lower part of the trunk, which gives off numerous buds and branches.
POLLEN, the powdery matter contained in the anther.
POLLEN-TUBE, the tube emitted by the pollen-grain after it is applied to the stigma.
POLLINIA, masses of pollen found in Orchids and Asclepiads.
POLYADELPHOUS, stamens united by their filaments so as to form more than two bundles.
POLYANDROUS, stamens above twenty.
POLYCOTYLEDONOUS, having many cotyledons, as in Firs.
POLYGAMOUS, plants bearing perfect as well as staminate and pistillate flowers.
POLYGYNŒCIAL, applied to multiple or confluent fruits.
POLYGYNOUS, having many pistils or styles.
POLYPETALOUS, a corolla composed of separate petals.
POLYPHYLLOUS, a calyx or involucre composed of separate leaflets.
POLYS, many, in composition *Poly;* in Latin *Multus.*
POLYSEPALOUS, a calyx composed of separate sepals.
POLYSPERMAL, containing many seeds.
POME, a fruit like the Apple and Pear.
PORES of the leaf, same as *Stomata.*
POROUS VESSELS, same as Pitted or Dotted vessels.
POSTERIOR, applied to the part of the flower placed next the axis; same as *Superior.*
PRÆFLORATION, same as *Æstivation.*
PRÆFOLIATION, same as *Vernation.*
PRICKLES, hardened epidermal appendages, of a nature similar to hairs.
PRIMINE, the outer coat of the ovule.
PROLIFEROUS, bearing abnormal buds.
PROSENCHYMA, fusiform tissue forming wood.
PROTERANDROUS, or PROTANDROUS, stamens reaching maturity before the pistil.
PROTEROGYNOUS, or PROTOGYNOUS, pistil reaching maturity before the stamens.
PROTHALLIUM, or PROTHALLUS, names given to the first part produced by the spore of some acrogens (as Ferns) in germination.
PROTOPLASM, the matter which is concerned in the early formation of cell-walls.
PSEUDO, false; in Latin, *Spurius.*
PSEUDO-BULB, the peculiar aerial stem of many epiphytic Orchids.
PUBESCENCE, short and soft hairs covering a surface, which is hence called *Pubescent.*
PULVINUS, cellular swelling at the point where the leaf-stalk joins the axis.
PUNCTATED, applied to the peculiar dotted woody fibres of Coniferæ, showing bordered pits.
PUTAMEN, the hard endocarp of some fruits.
PYXIS and PYXIDIUM, a capsule opening by a lid.

QUADRI, in composition, means four times.
QUADRIFID, four-cleft, cut down into four parts to about the middle.
QUADRILOCULAR, having four loculaments.
QUADRIPARTITE, divided deeply into four parts.
QUARTINE, the fourth coat of the ovule, which often is changed into albumen.
QUATERNATE, leaves coming off in fours from one point.
QUINARY, composed of five parts, or of a multiple of five.
QUINATE, five leaves coming off from one point.
QUINQUE, in compound words means five.
QUINQUEFID, five-cleft, cut into five parts as far as the middle.
QUINQUELOCULAR, having five loculaments.
QUINQUEPARTITE, divided deeply into five parts.

RACE, a permanent variety.
RACEME, cluster, inflorescence in which there is an elongated primary axis bearing stalked flowers.
RACEMOSE, flowering in racemes.
RACHIS, the axis of inflorescence; also applied to the stalk of the frond in Ferns, and to the common

stalk bearing the alternate spikelets in some Grasses.

RADIANT, applied to flowers which form a ray-like appearance, as seen in Umbelliferæ and in Viburnum, etc.

RADICAL, belonging to the root, as radical hairs.

RADICLE, the young root of the embryo.

RADIUS, the ray or outer part of the heads of Composite flowers.

RAPHE, the line which connects the hilum and the chalaza in anatropal ovules.

RAPHIDES, crystals found in cells, which are hence called *Raphidian*.

RAY, applied to the expanded outer flowers of a capitulum or umbel.

RECEPTACLE, the flattened end of the peduncle or rachis, bearing numerous flowers in a head; applied also generally to the extremity of the peduncle or pedicel.

RECURVED, bent back.

REGULAR, applied to an organ, the parts of which are of similar form and size.

RENIFORM, in shape like a kidney.

REPLUM, a longitudinal division in a pod, formed by the placenta, as in Cruciferæ.

RETICULATED, netted, applied to leaves having a network of anastomosing veins.

RETUSE, when the extremity is broad, blunt, and slightly depressed.

REVOLUTE, leaf with its edges rolled backwards in vernation.

RHIZA, in words derived from the Greek, means root.

RHIZOME, a stem creeping horizontally, more or less covered by the soil, giving off buds above and roots below.

RHOMBOID, quadrangular form, not square, with equal sides.

RINGENT, a labiate flower, in which the upper lip is much arched.

ROOT-STOCK, same as *Rhizome*.

ROSACEOUS, applied to corollas having separate sessile petals like the Rose.

ROSTELLUM, the modified stigma of the upper pistil of Orchids. It includes, or is formed, of viscid matter. The pollen-masses, in many Orchids, are firmly attached to a portion of its exterior membrane, which is removed along with the pollen-masses by insects.

ROSTRATE, beaked, having a long sharp point.

ROTATE, a gamopetalous corolla with a short tube, the limb spreading out more or less at right angles.

ROTATION or GYRATION, a peculiar circulation of the cell sap, seen in Hydrocharidaceæ, Chara, etc.

RUMINATE, applied to mottled albumen, as in Nutmeg.

RUNCINATE, a pinnatifid leaf with a triangular termination and sharp divisions pointing downwards, as in Dandelion.

RUNNER, a prostrate shoot rooting at its end; a stole.

SAGITTATE, like an arrow, a leaf having two prolonged sharp-pointed lobes projecting downwards beyond the insertion of the petiole.

SALVER-SHAPED, same as *Hypocrateriform*.

SAMARA, a winged dry fruit, as in the Elm.

SARMENTUM, sometimes meaning the same as *Flagellum*, or runner, at other times applied to a twining stem which supports itself by means of others.

SCABROUS, rough, covered with very stiff short hairs; *Scabriusculus*, somewhat rough.

SCALARIFORM, vessels having bars like a ladder, seen in Ferns.

SCANDENT, climbing by means of supports, as on a wall or rock.

SCAPE, a naked flower-stalk, bearing one or more flowers arising from a short axis, and usually with radical leaves at its base.

SCARIOUS, having the consistence of a dry scale, membranous, and shrivelled.

SCION, the young twig used as a graft.

SCORPIOIDAL, like the tail of a scorpion, a peculiar twisted cymose inflorescence, as in Boraginaceæ.

SECUND, turned to one side.

SECUNDINE, the second coat of the ovule within the primine.

SEGREGATE, separated from each other.

SEMI, half, same as the Greek *Hemi*.

SEMINAL, applied to the cotyledons, or seed-leaves.

SEPAL, one of the leaflets forming the calyx.

SEPTATE, divided by septa or partitions.

SEPTEM, seven, in Greek *Hepta*.
SEPTENATE, a compound leaf with seven leaflets coming off from one point.
SEPTICIDAL, dehiscence of a seed-vessel through the septa or edges of the carpels.
SEPTIFRAGAL, dehiscence of a seed-vessel through the back of the loculaments, the valves also separating from the septa.
SEPTULATE, having spurious transverse dissepiments.
SEPTUM, a division in an ovary formed by the sides of the carpels.
SERICEOUS, silky, covered with fine close-pressed hairs.
SERRATE or SERRATED, having sharp processes arranged like the teeth of a saw. *Biserrate*, when these are alternately large and small, or when the teeth are themselves serrated.
SERRATURES, pointed marginal divisions arranged like the teeth of a saw.
SESSILE, without a stalk, as a leaf without a petiole.
SETA, a bristle or sharp hair; also applied to the gland-tipped hairs of Rosaceæ and Hieracia; and to the stalk bearing the theca in Mosses.
SETACEOUS, in the form of bristles.
SEX, in Latin, six, same as Greek *Hexa*.
SILICULA or SILICLE, a short pod with a double placenta and a replum, as in some Cruciferæ.
SILICULOSÆ, bearing a silicle.
SILIQUA, a long pod similar in structure to the silicula.
SILIQUOSÆ, bearing a siliqua.
SIMPLE, not branching, not divided into separate parts; *Simple fruits* are those formed by one flower.
SINUATED, the margin having numerous large obtuse indentations.
SINUOUS, with a wavy or flexuous margin.
SOBOLES, a creeping underground stem.
SORUS, a cluster of sporangia in Ferns.
SPADIX, a succulent spike bearing staminate and pistillate flowers, as in Arum.
SPATHACEOUS, having the aspect and membranous consistence of a spathe.
SPATHE, large membranous bract covering numerous flowers.
SPATHULATE, shaped like a spathula, applied to a leaf having a linear form, enlarging suddenly into a rounded extremity, as in Daisy.
SPAWN, same as *Mycelium*.
SPECIFIC CHARACTER, the essential character of a species.
SPERMATOZOIDS, moving filaments contained in the antheridia of Cryptogams; same as *Phytozoa* and *Antherozoids*.
SPERMODERM, the general covering of the seed. Sometimes applied to the episperm or outer covering.
SPIKE, inflorescence consisting of numerous flowers sessile on an axis.
SPIKELET, small cluster of sessile flowers in Grasses.
SPINE or THORN, an abortive branch with a hard sharp point.
SPIRAL VESSELS, having a spiral fibre coiled up inside a tube.
SPIROLOBEÆ, Cruciferæ having the cotyledons folded transversely, the radicle being dorsal.
SPONGIOLE or SPONGELET, the cellular extremity of a young root.
SPORANGIUM, a case containing spores.
SPORE, a cellular germinating body in Cryptogamic plants.
SPUR, same as *Calcar*.
SQUAMA, a scale; also applied to bracts on the receptacle of Compositæ, to bracts in the inflorescence of Amentiferæ, and to the lodiculæ of Grasses.
SQUAMOSE, covered with scales.
STAMEN, one of the essential reproductive organs of the flower, formed by a stalk or filament and the anther containing pollen.
STAMINATE and STAMINIFEROUS, applied to a flower having stamens only and no pistil, or to a plant bearing staminate flowers only.
STAMINODIUM, an abortive stamen.
STANDARD, same as *Vexillum*.
STELLATE, arranged like a star.
STERILE, staminate flowers not bearing fruit.
STICHOUS, at the termination of words means a row, as *distichous*, in two rows.
STIGMA, the upper cellular secreting portion of the pistil, not covered with epidermis: *Stigmatic*, belonging to the stigma.
STIMULUS, a sting, applied to stinging hairs with an irritating secretion at the base.
STIPE, the stem of Palms and of Tree-ferns; also applied to the stalk of Fern fronds, and to the

stalk bearing the pileus in Agarics.
STIPULATE, furnished with stipules.
STIPULE, leaflet at the base of other leaves, having a lateral position, and more or less changed either in form or texture.
STOLON, STOLE, a sucker, at first aerial, and then turning downwards and rooting.
STOLONIFEROUS, having creeping runners which root at the joints.
STOMATES and STOMATA, openings in the epidermis of plants, especially in the leaves.
STRAP-SHAPED, same as *Ligulate;* linear, or about six times as long as broad.
STRIATED, marked by streaks or striæ.
STRIPES, another name for the Vittæ of Umbelliferæ.
STROBILUS, a cone, applied to the fruit of Firs as well as to that of the Hop.
STYLE, the stalk interposed between the ovary and the stigma.
STYLOPOD, an epigynous disk seen at the base of the styles of Umbelliferæ.
SUB, in composition, means a near approach to, as sub-rotund means nearly round.
SUBEROUS, having a corky texture.
SUBTERRANEAN, underground.
SUBULATE, shaped like a cobbler's awl.
SUPERIOR, applied to the ovary when free, *i.e.* placed above the calyx; to the calyx when it is placed above the ovary; to the part of a flower placed next the axis.
SUSPENDED, applied to an ovule which hangs from a point a little below the apex of the ovary.
SUSPENSOR, cord suspending the young embryo.
SUTURE, the part where separate organs unite, or where the edges of a folded organ adhere; the *ventral suture* of the ovary is that next the centre of the flower; the *dorsal suture* corresponds to the midrib.
SYMMETRY, applied to the flower, has reference to the parts being of the same number, or multiples of each other.
SYMPETALOUS, union or cohesion of petals.
SYMPHYLLOUS, union or cohesion of parts of a perianth.
SYN, in composition, means united.
SYNANTHEROUS, anthers united.
SYNANTHOS, flowers united together.
SYNCARPOUS, carpels united so as to form one ovary or pistil.
SYNGENESIOUS, same as *Synantherous.*
SYNSEPALOUS, coherent sepals.

TAP-ROOT, root descending deeply in a tapering undivided manner.
TENDRIL. See *Cirrus.*
TERETE, nearly cylindrical, somewhat tapering into a very elongated cone, the transverse section nearly circular.
TERNARY, parts arranged in threes.
TERNATE, compound leaves composed of three leaflets.
TESTA, the outer covering of the seed; some apply it to the coverings taken collectively.
TETRA, in Greek words, four; in Latin *Quater* or *Quadri.*
TETRADYNAMOUS, four long stamens and two short, as in Cruciferæ.
TETRAGYNOUS, having four carpels or four styles.
TETRAMEROUS, composed of four parts; a flower is tetramerous when its envelopes are in fours, or multiples of that number.
TETRANDROUS, having four stamens.
TETRASPORE, a germinating body in Algæ composed of four spore-like cells; but also applied to those formed of three spore-like cells.
THALAMIFLORAL, parts of the floral envelope inserted separately into the receptacle or thalamus.
THALAMUS, the receptacle of the flower, or the part of the peduncle into which the floral organs are inserted.
THALLOGENS or THALLOPHYTES, plants producing a thallus.
THALLUS, cellular expansion in Lichens and other Cryptogams, bearing the fructification.
THECA, sporangium or spore-case containing spores.
THECAPHORE, a stalk supporting the ovary.
THORN, same as *Spine.*
THROAT, the orifice of a gamopetalous flower.
THRUM-EYED, flowers having short styles, where the stigma does not appear at the upper part of the tube of the corolla, as in Primula.
TIGELLUS, the young embryonic axis.
TILLERING, giving out buds from the

lower part of the stalks of wheat and other cereal grains.

Tomentose, covered with entangled cottony pubescence.

Torus, another name for thalamus; sometimes applied to a much developed thalamus, as in Nelumbium.

Trachea, a name for spiral vessels.

Transpiration, the exhalation of fluids by leaves, etc.

Treis, three; **Tris**, thrice, in composition *Tri*.

Triadelphous, stamens united in three bundles by their filaments.

Triandrous, having three stamens.

Triangular, having three angles, the faces being flat.

Trichotomous, divided successively into three branches.

Tricostate, three-ribbed, ribs from the base.

Trifid, three-cleft, a leaf divided into three segments which reach to the middle.

Trifoliate or **Trifoliolate**, same as *Ternate*. When the three leaves come off at one point the leaf is *ternately-trifoliate;* when there is a terminal stalked leaflet and two lateral ones it is *pinnately-trifoliate*.

Trigonous, having three angles, the faces being convex.

Trigynous, having three carpels or three styles.

Trilocular, having three loculaments.

Trimerous, composed of three parts; *a trimerous flower* has its envelopes in threes or multiples of three.

Trimorphic, three forms of flowers in one species, each on a different plant, with stamens and pistils of different lengths.

Tripartite, deeply divided into three.

Tripinnate, a compound leaf three times divided in a pinnate manner.

Tripinnatifid, a pinnatifid leaf with the segments twice divided in a pinnatifid manner.

Triquetrous, having three angles, the faces being concave.

Tristichous, in three rows.

Triternate, three times divided in a ternate manner.

Truncate, terminating abruptly, as if cut off at the end.

Tuber, a thickened underground stem or branch, as the potato.

Tubercule, the swollen root of some terrestrial Orchids.

Tubular, applied to the regular florets of the Compositæ.

Umbel, inflorescence in which numerous stalked flowers arise from one point.

Umbellule, a small umbel, seen in the compound umbellate flowers of many Umbelliferæ.

Uncinate, provided with an *Uncus* or hooked process.

Undecim, eleven, in Greek *Endeca*.

Unguis, claw, the narrowed part of a petal; such a petal is called *Unguiculate*.

Uni, in composition, one, same as Greek *Mono*.

Unilocular, having a single *Loculus* or cavity.

Uniparous, a form of cymose inflorescence.

Vacuoles, clear spaces in the protoplasm of a cell.

Valvate, opening by valves, like the parts of certain seed-vessels, which separate at the edges of the carpels.

Valvate Æstivation, and **Vernation**, when leaves in the flower-bud and leaf-bud are applied to each other by their margins only.

Valves, the portions which separate in some dehiscent capsules. A name also given to the parts of the flower of grasses.

Vascular tissue, composed of spiral vessels and their modifications.

Veins, bundles of vessels in leaves.

Velum, veil, the cellular covering of the gills of an Agaric in its early state.

Venation, the arrangement of the veins.

Ventral, applied to the part of the carpel which is next the axis.

Vernation, the arrangement of the leaves in the bud.

Versatile, applied to an anther which is attached by one point of its back to the filament, and hence is very easily turned about.

Verticil, a whorl, parts arranged opposite to each other at the same level, or, in other words, in a circle round an axis. The parts are said to be *Verticillate*.

Verticillaster, a false whorl, formed of two nearly sessile cymes placed in the axils of opposite leaves, as in Dead-nettle.

VESICLE, another name for a cell or utricle.

VESSELS, tubes with closed extremities.

VEXILLUM, standard, the upper or posterior petal of a papilionaceous flower.

VIGINTI, twenty, same as Greek *Icosi*.

VITTÆ, cells or clavate tubes containing oil in the pericarp of Umbelliferæ.

VIVIPAROUS, plants producing leaf-buds in place of fruit.

VOLVA, a wrapper, the organ enclosing the parts of fungi in their young state.

WHORL, see *Verticil*.

WHORLED, see *Verticillate*.

WINGS, the two lateral petals of a papilionaceous flower, or the broad flat edge of any organ.

XANTHOPHYLL, yellow colouring matter in plants.

XYLEM, the wood portion of a fibro-vascular bundle, formed usually of thick-walled cells.

ZOOSPORE, a moving spore provided with cilia.

ZYGOSPORE, a compound spore, formed by conjugating cells, as in Fungi.

ABBREVIATIONS AND SYMBOLS.

THE names of Authors are abridged in Botanical works by giving the first letter or syllable, etc.—Thus L. stands for Linnæus; DC. for De Candolle; Br. for Brown; Lam. and Lmk. for Lamarck; Hook. for Hooker; Hook. fil. for Hooker junior; Lind. for Lindley; Arn. for Arnott; H. and B. for Humboldt and Bonpland; H. B. and K. for Humboldt, Bonpland, and Kunth; W. and A. for Wight and Arnott; Benth. for Bentham; Berk. for Berkeley; Bab. for Babington, etc.

The Symbol ∞ or 00 means an indefinite number; in the case of stamens it means above 20.

○ ⊙ or A. means a Monocarpic annual plant; flowering and fruiting within the year and then dying.

♂ ⊙⊙ or B. means a Biennial plant; flowering and fruiting in the second year.

♃ △ or P. means a perennial plant; Rhizocarpic.

♄ or Sh. means a shrub; 5 means a tree under 25 feet; T. or 5 a Tree above 25 feet.

‿ means a climber;) turning to the left; (turning to the right.

O = Cotyledons accumbent, radicle lateral; Pleurorhizea.

O || Cotyledons incumbent, radicle dorsal; Notorhizeæ.

O≫ Cotyledons conduplicate, radicle dorsal; Orthoploceæ.

O || || Cotyledons plicate or folded, radicle dorsal; Spirolobeæ.

O || || || Cotyledons biplicate or twice folded, radicle dorsal; Diplecolobeæ.

☿ Flower, having both stamens and pistil.

♂ Staminiferous, staminate, or sterile flower.

♀ Pistilliferous, pistillate, or fertile flower.

♂—♀ Monœcious or Monoicous species, having staminate and pistillate flowers on the same plant.

♂:♀ Diœcious or Dioicous species, having staminate and pistillate flowers on different plants.

! Indicates certainty as to a genus or species described by the author quoted.

? Indicates doubt as to the genus or species.

O or 0 indicates the absence of a part.

In giving the Formulæ for flowers the following marks are used:—
S for sepals, P for petals, St for stamens, C for carpels, $\widehat{S}$ united or coherent sepals, $\widehat{P}$ united or coherent petals, $\widehat{St}$ united or coherent stamens, $\widehat{C}$ united or coherent carpels (see also page 202).

INDEX.

THE END.

Printed by R. & R. CLARK, *Edinburgh.*